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**Ford Motor Company**

# Draft Baseline Human Health Risk Assessment for Site-Related Groundwater

Ringwood Mines/Landfill Site
Ringwood, New Jersey

May 2015

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## Executive Summary

This Baseline Human Health Risk Assessment (BHHRA) for Site-related Groundwater at the Ringwood Superfund Site (Site) has been prepared in compliance with the May 2010 Administrative Order on Consent for the Site between the United States Environmental Protection Agency (USEPA) and Ford Motor Company (Ford). This BHHRA evaluates the analytical and Site characterization data generated during a Remedial Investigation conducted by ARCADIS U.S., Inc. (ARCADIS) on behalf of Ford as documented in the January 2015 Draft *Site-Related Groundwater Remedial Investigation Report* (GW RIR; ARCADIS 2015). This analysis shows that all potential cancer and non-cancer risks estimated are within or below USEPA's benchmarks.

This BHHRA was developed following USEPA guidance and policy and prepared via an iterative process, where specific assumptions and procedures were discussed with and approved by USEPA prior to the completion of the assessment. Exposure scenarios were developed and exposure parameters were identified using a variety of sources, including USEPA's Exposure Factors Handbook (USEPA 2011) and input from USEPA. This approach was developed to provide a high level of confidence that the hypothetical future risks at the Site are not underestimated.

The analysis estimates potential risks to a hypothetical future resident receptor who could be exposed to groundwater from the Site. Because New Jersey Department of Environmental Protection (NJDEP) has classified the aquifers at the Site as Class IIA, the hypothetical future resident is assumed to be exposed to groundwater used as a potable water source via ingestion, dermal contact while showering, and inhalation of volatile compounds while showering, even though groundwater is not used as a potable water source at the Site and it is highly unlikely that it would be used as such in the future[1]. Water for potable use is supplied to residents in the Borough of Ringwood from well fields located within a different watershed approximately 2 miles southeast of the Site.

As discussed in detail in Section 5.1, all constituents detected at least once in Site-related groundwater (Section 4) were screened as constituents of potential concern (COPCs). All COPCs were retained for analysis in this BHHRA, including benzene,

[1] Groundwater is not used for potable purposes, and future use for drinking or domestic purposes is unlikely given the high naturally occurring hardness, including elevated iron and manganese concentrations found in groundwater in historically mined areas, as well as at upgradient, background well locations which create objectionable odor, color, and taste as well as the low yield of water volumes (ARCADIS 2015).

lead, and arsenic which were determined to be primary constituents of concerns for Site-related groundwater in the GW RIR (ARCADIS 2015). This BHHRA includes evaluations of both reasonable maximum exposure (RME) and central tendency (CT) scenarios.

**RME Summary**

The cumulative potential cancer risk for the hypothetical future resident RME scenario for the adult, older child (or youth), and young child is $1x10^{-4}$, which is at the upper limit of USEPA's acceptable cancer risk range. The potential cancer and non-cancer risk estimates are summarized in Tables 7.1.RME, 7.2.RME, 7.3 RME, respectively. In addition, as shown in Tables 9.1 RME, 9.2 RME, and 9.3 RME, when the hazard index is assessed by target organ for the future hypothetical resident RME scenario for the adult, older child, and young child, all target organ hazard indices are below the USEPA's target hazard index limit of 1

**CT Summary**

The cumulative potential cancer risk for the hypothetical future resident CT scenario for the older child (or youth) and young child is $1x10^{-5}$, which is within USEPA's acceptable risk range as shown in Tables 7.2.CT and 7.3.CT, respectively. When the non-cancer hazard index is assessed by target organ for the future hypothetical resident CT scenario for the young child and older child, all target organ hazard indices are below the USEPA's target hazard index of 1. Tables 7.2.CT and 7.3.CT present the potential cancer and non-cancer risks for the older child and young child resident, respectively.

**Lead Summary**

The USEPA adult lead model, which was used to predict blood lead levels in the adult and older child, only includes concentrations of lead in soil. Therefore, potential hazards from Site-related lead exposures in groundwater could be estimated only for the young child hypothetical future resident scenario which represents the most conservative exposure scenario. Even with this most conservative exposure scenario, lead concentrations in groundwater result in estimated blood lead levels that are predicted to be below USEPA's benchmark for both the hypothetical future resident young child RME scenario and the young child hypothetical future resident CT scenario.

# 1. Introduction

On behalf of Ford Motor Company (Ford), ARCADIS U.S., Inc. (ARCADIS) has prepared this Baseline Human Health Risk Assessment (BHHRA) for the Site-Related Groundwater Area of Concern at the Ringwood Mines/Landfill Site located in Ringwood, New Jersey (Site). This BHHRA has been prepared in compliance with the May 2010 Administrative Order on Consent for the Site between the United States Environmental Protection Agency (USEPA) and Ford. This BHHRA evaluates the analytical and Site characterization data generated during a Remedial Investigation (RI) conducted by ARCADIS on behalf of Ford as documented in the draft January 2015 *Site-Related Groundwater Remedial Investigation Report* (GW RIR; ARCADIS 2015).

The Site is approximately 500 acres in size (Figure 1). It is 0.5 mile wide and approximately 1.5 miles long. It includes forested areas, abandoned mine shafts, landfills, industrial refuse disposal areas, residential lots, and a portion of Ringwood State Park. A number of investigations have taken place at the Site and have resulted in the removal of Ford-related paint waste materials from several isolated areas within the Site.

USEPA has requested that human health risk assessments be focused on three land areas of concern (AC), including the Peter's Mine Pit (PMP) Area, the O'Connor Disposal Area (OCDA), the Cannon Mine Pit (CMP) Area, as well as Site-Related Groundwater. The three land AC locations are shown in Figure 2. A BHHRA for the PMP Area land AC was approved by USEPA on April 25, 2012, and BHHRAs for the CMP Area and the OCDA ACs were approved by USEPA on September 13, 2013. In accordance with an agreement with USEPA, this BHHRA focuses on the Site-Related Groundwater AC and considers hypothetical future human exposures to only Site-related groundwater.

This BHHRA was prepared via an iterative process, where specific assumptions and procedures were discussed with and approved by USEPA prior to the completion of the assessment. Further discussion regarding this process is provided in Section 7.

Based on the analysis presented herein, all potential cancer and non-cancer risks estimated in this BHHRA are within or below USEPA's benchmarks.

### 1.1 Objectives and Purpose

This BHHRA was performed to assess hypothetical future health risks associated with future potential use of Site-related groundwater as a potable drinking water resource and for showering, etc., assuming no additional remedial actions are undertaken. Results of this BHHRA will be used to make a series of Site-specific risk management decisions during the remedy-selection process. This BHHRA evaluates the potential future effects of exposure to constituents of potential concern (COPCs) reported in Site-related groundwater.

Although there is no current use of groundwater at the Site, this BHHRA describes the data, COPCs, toxicity data, exposure scenarios, exposure assumptions, and potential risk to evaluate the reasonably anticipated potential future uses of Site-related groundwater based on the NJDEP classification of the aquifers at the Site as Class IIA. To provide perspective, this BHHRA is organized to include a general discussion of the larger Site and the remedial activities that have been conducted at the Site to date. In accordance with USEPA guidance, risk estimates are provided for both reasonable maximum exposure (RME) and central tendency (CT) exposure scenarios for each receptor group.

### 1.2 General Approach

This BHHRA is an integral part of the study of the Site and is designed to assist risk managers in making informed decisions regarding actions necessary to address hazardous substances. This BHHRA focuses on potential human health impacts associated with exposure to Site-related constituents in groundwater. Although groundwater is not currently utilized at the Site, the concentrations of COPCs reported in Site-related groundwater are combined with assumptions about the ways that people may be exposed to that medium if groundwater is used in the future in order to estimate future potential Site-related risks. These risks are then compared to USEPA's acceptable risk range and target hazard index to determine if there is a potential for unacceptable health risks to occur as a result of exposure to Site-related groundwater if groundwater is ever used for potable purposes in the future which, again, is unlikely even though NJDEP has classified the aquifers at the Site as Class IIA.

# 2. Site Description/History

## 2.1 Site Description

As shown on Figure 1, the Site is located in the New Jersey Highlands, a mountainous part of New Jersey. It is approximately 500 acres in size, is 0.5 mile wide, and approximately 1.5 miles long. The Site consists of moderately rugged forested areas, open areas of overgrown vegetation, abandoned mine shafts and surface pits, an air shaft, a closed municipal landfill, small surficial depositional areas, automobile carcasses, a municipal recycling center, the Borough of Ringwood Department of Public Works Garage, and residential properties. Ringwood State Park is located north and east of the Site.

The Site is bordered by mountainous ridges to the west (Whaleback Mountain, Mine Hill) and north (Hope Mountain, Unnamed Mountain) and lower hills and ridges to the east and south, and is situated on the western side of a valley defined by the Wanaque River watershed. As shown in Figure 2, there are four primary streams in different parts of the Site that are tributaries to Ringwood Creek: Mine Brook (western and southern areas), Peters Mine Brook (a drainage swale in the central part of the Site), Park Brook (north-central area), and an unnamed tributary of Ringwood Creek identified as North Brook (northern area). The Ringwood Creek watershed drains to the Wanaque Reservoir, which, as shown on Figure 2, is approximately 2 miles from the PMP Area and approximately 0.75 mile from the southern Site boundary in the vicinity of the CMP Area.

There are paved roads in the residential areas and leading to former mining areas. These roads are Peters Mine Road, Cannon Mine Road, Van Dunk Lane, Sheehan Drive, Milligan Drive, Horseshoe Bend Road, and Petzold Avenue. There are also many former mine roads and trails. Some are dirt roads and others are covered with asphalt, gravel, or mine tailings. A few of the trails and former mine roads are in various states of natural reclamation.

The Borough of Ringwood Department of Public Works Garage is located near the intersection of Peters Mine Road and Margaret King Avenue, and the Borough Recycling Center is located approximately 0.5 mile north on Peters Mine Road. There is a Public Service Electric and Gas Company (PSE&G) power substation on the eastern side of Peters Mine Road, approximately 400 yards north of the Margaret King Avenue intersection.

### 2.2 Site History

The Ringwood Mines/Landfill Site is a historical iron ore mining site that operated from the 1700s until the 1950s. In 1942, the U.S. Government purchased the Upper Ringwood Area (approximately 870 acres) and invested heavily in the mines to prepare them for potential use in World War II.

Activities conducted by the U.S. Government's lessee, the Alan Wood Steel Company, from 1942 until 1945 included the reconstruction of a number of mine-related structures; refurbishment of the mines' water supply system; dewatering of the mines; excavation and on-site disposal of waste rock and mine tailings (pulverized and small pieces of mined rock and mineral materials discarded after separation from iron ore during the mining process); reopening, enlarging, reconditioning, and extending of the original mine levels; production and processing of some iron ore; and related activities (Batcheller 1948; Esso Oilways 1953). The U.S. Government sold the mines in 1947 to a private party, but the property reverted to the U.S. Government one year later after the private party filed for bankruptcy. As a result of this long history of mining operations, large volumes of mine tailings were disposed of on site and then re-worked or scattered across the Site.

In 1958, the U.S. Government sold the property to Pittsburgh Pacific Company, and in 1965 Pittsburgh Pacific Company sold the property to the Ringwood Realty Corporation, a former subsidiary of Ford. In 1967, Ringwood Realty contracted O'Connor Trucking and Haulage Company (O'Connor) to dispose of paper, cardboard, wood, metal, plastic scrap, general trash, paint waste, scrap drums, car parts, and other non-liquid plant wastes from Ford's former Mahwah assembly plant. The O'Connor agreement ran from 1967 until 1971, and required O'Connor to properly dispose of Ford wastes at three locations on the Ringwood Site: the PMP Area, the CMP Area, and the OCDA.

In November 1970, Ringwood Realty donated 290 acres of the Site to the Ringwood Solid Waste Management Authority. By November 1971, Ringwood Realty had sold all but 145 acres of the Site, and by December 1973 Ringwood Realty no longer owned any portion of the Site. Disposition of various solid wastes by others occurred before, during, and after the 4-year period during which Ford-related wastes were disposed of at the Site.

Today, this former mining Site has numerous former mine pits, prospect pits, underground mine workings, and mine waste disposal areas. The material present in the ACs (PMP, CMP, and OCDA) consists of fill cover soil, mine tailings (PMP Area and OCDA only), construction and demolition debris, general manufacturing wastes, general municipal-type wastes, dried paint pieces (PMP Area and OCDA only), drum remnants, and miscellaneous fill. After disposal ceased, these ACs were graded and an approximately two-foot clean fill cap was placed.

### 2.2.1 Potential Sources of Constituents

Based on the history of disposal operations by several entities at the Site, the potential source of the constituents reported in groundwater can be related to some or all of the historical Site operations, including:

- Mining operations
- Post-mining automobile disposal and structure fires
- Solid waste disposal
- Mahwah assembly plant waste disposal

As previously described, the vast majority of the 500-acre Site is primarily forested land, untouched by these historical operations. However, as described in more detail below, historical disposal activities and practices have affected the mining pits (PMP and CMP), mine tailings disposal areas (OCDA), and the various paint waste disposal areas (SR) areas.

*Mining Operations*

As a result of mining operations from the 1700s through the 1950s, mine tailings were disposed over a broad area of the Site. These mine tailings later became commingled in some places with dried paint pieces, Ford solid waste, and municipal refuse, depending upon the location at the Site. Arsenic and lead are present in these mine tailings as well as native soil and host rock; however, lead concentrations are less than its 400 milligram per kilogram (mg/kg) New Jersey Soil Residential Direct Contact Remediation Standard in native soil, rock, and mine tailings (ARCADIS 2008a, 2008b). In addition to the introduction of mine tailings at the Site, the mining operations commonly used petrochemicals and fuels to support the mining activities. Evidence of this was uncovered in 2006, when four underground storage tanks (USTs) were discovered (and subsequently removed and disposed of by Ford) during a soil removal action along the north side of PMP.

Subsequent research revealed that these USTs were likely installed in the mid to late 1940s, when the U.S. Government was renovating Peters Mine. A historical Ringwood Realty map shows that they were located adjacent to a small shed-like structure identified on the legend as an "Oil and Grease Shed". Aerial photographs from 1951 also reveal staining on the ground close to the USTs. Based on water samples collected from inside the tanks analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons, polychlorinated biphenyls, and metals, it appears that the USTs were used to store diesel fuel to run construction and mine equipment, and possibly power electric generators. Use of other oils and grease products, and the residuals associated with the materials and machinery left behind when the mine was abandoned, also present potential sources of benzene and lead to the environment.

Mining operations were also supported by an on-site power plant that was located on the southwest side of the pit (as shown on 1944 mine maps). It is unclear at this time whether the plant was supported by coal, fuel oil, or both.

At the end of the time period when mine operations ceased (in the 1950s), a large fire burned the PMP mill building and some of the support buildings connected by conveyor. Today, some of the charred remains and burnt wood can be found north of the former mill building. Burnt wood has also been found in test trenches installed in the OCDA.

*Post-mining Automobile Disposal and Structure Fires*

There is documented evidence that junked cars were placed in the mine pits and other areas of the Site. In a 1965 article in the Patterson Morning Call, Frank Lynford, vice-president of Ringwood Realty, estimated the number of abandoned cars to be more than 10,000 (Yesenosky 1965). Historical junk car disposal was also documented by the New Jersey Mine Safety Bureau in 1964 and 1965. Under the direction of State and local authorities, the junked cars were removed from the mine pits by Ringwood Realty in 1965 prior to the mine pits being closed as instructed and approved by the New Jersey Mine Safety Bureau (Yesenosky, 1965; Getz, November 16,1966).

A major fire at the Peters Mine occurred in July 1964, burning buildings and some of the mine pit structure (Herald News, July 6, 1964). Historical newspaper articles also document numerous fires in the Cannon Mine Pit during the period of solid waste disposal (Suburban Sunday Trend, March 1, 1970).

*Solid Waste Disposal*

As previously described, solid waste was disposed of at the Site before, during, and after the 4-year period during which Ford-related wastes were disposed of at the Site. The Site has also been subject to widespread dumping by the public. Waste materials include abandoned automobiles, white goods, tires, household trash, and general debris.

*Mahwah Facility Disposal*

As described previously, Ford contracted O'Connor to dispose of paint waste and other non-liquid plant wastes from Ford's former Mahwah assembly plant at the three ACs from 1967 until 1971. There is also evidence that waste was disposed in other areas readily accessible by dump trucks. Further, some of the waste, including dried paint pieces, was likely relocated by construction crews and others when fill material was transferred to other locations on the Site. The dried paint pieces found in areas outside the ACs—referred to as the SR areas—have been removed and disposed off-site. Paint waste can contain petroleum-related VOCs and SVOCs, along with antimony, arsenic, barium, chromium, and lead.

Source removal activities to address Ford-related disposal at the Site has resulted in the removal of over 50,400 tons of surficial paint waste, soil, and other waste materials. Ford has and will continue to remove additional dried paint pieces if any are discovered at the Site.

Disposal activities, other than Ford's paint waste disposal, may have also contributed to environmental impacts at the Site. The focus of the GW RIR (ARCADIS 2015) was on the characterization of groundwater and surface water as it relates to paint waste disposed by Ford; however, the contribution of background conditions due to mine tailings and other disposal operations are also discussed, as appropriate.

## 2.3 Geology/Hydrogeology

### 2.3.1 Geology

The Site is located in the southeastern extension of the New England Highlands Physiographic Province. The portion located in New Jersey is known as the New Jersey Highlands. In areas of well-foliated gneiss, the topography of the New Jersey Highlands consists of northeast-southwest trending parallel ridges. The more common, less foliated gneiss forms rounded or broad-topped topographic highs. Granite gneiss and pegmatite form sharp ridges separated by narrow troughs underlain by less resistant gneiss. Major cross faults are visible as trench-like features that interrupt drainage. Those faults generally strike approximately east-west across the predominant northeast strike of the major ridges and valleys (Hotz 1953).

Structural features of the New Jersey Highlands, which are regionally related either spatially or tectonically, include folds, faults, lineation trends, and jointing. The New Jersey Highlands has experienced a complex history of folding and faulting, the result of both Precambrian and post-Precambrian tectonism. The formation of the New Jersey Highlands and the associated faulting and folding, which produced structural complexities in the region, occurred during the closing periods of the Paleozoic Era concurrent with the formation of the Appalachian Mountains (Woodward-Clyde Consultants [WCC] 1988).

The New Jersey Highlands in Passaic County are drained by the Pequannock, Wanaque, and Ramapo Rivers, which ultimately join to form the Pompton River, a tributary of the Passaic River. The drainage pattern north of the terminal moraine in the New Jersey Highlands is classified as deranged, and is marked by many poorly drained areas of lakes and swamps. Greenwood Lake and Lake Hopatcong are large lakes formed by the blocking of pre-glacial drainage courses. South of the terminal moraine, stream drainage generally follows structural valleys toward the southwest (WCC 1988).

Unconsolidated soil and sediment deposits are primarily confined to the stream valleys and corridors. Based on the findings of the RI, the unconsolidated deposits are thickest in the eastern and southern parts of the Site. The overburden ranges from approximately 25 to 50 feet thick. The overburden consists of the Rahway Till dating from the Pleistocene age and is reddish-brown, light reddish-brown, reddish-yellow silty sand to sandy silt containing some to many sub-round and sub-angular pebbles and few sub-rounded boulders. The matrix is compact, non-plastic to slightly plastic with coarse sub-horizontal fissile structures, and the clasts are composed of red and gray sandstone and siltstone, gray gneiss, and white to gray quartz and quartzite gravel. Boulders are mainly gneiss, and a few are quartzite or gray and red sandstone (Stanford 2002).

Bedrock is encountered at approximately 25 to 50 feet below ground surface (bgs). Bedrock consists of Mesoproterozoic age metasedimentary rocks of the Vernon Supersuite and gneisses of the Losee Metamorphic Suite, approximately 1.3 billion years old. The rock primarily consists of calc-alkaline and plagioclase gneisses. There are occurrences of pegmatite, pyroxene-amphibolites, biotite-quartz feldspar gneiss, and magnetite iron ore. The structural nature of bedrock at the Site is complex. The gneisses are moderately to well foliated, have mineral lineation, and display evidence of three distinct folding events. Joints are prevalent in the bedrock and are characteristically moderate to well developed, planar, typically unmineralized, and moderately to steeply dipping with spacing from 1 foot to several tens of feet (Volkert 2008).

The iron ore found in Ringwood is thought to be hydrothermal deposits consisting primarily of magnetite that replaced pyroxene amphibolites and skarn rocks. The iron ore formed around the same time as emplacement of granite and pegmatite, approximately 950 million years ago.

### 2.3.2 Hydrogeology

Groundwater at the Site occurs in both overburden and bedrock, but only in overburden is it sufficiently thick to be continually saturated, usually a thickness observed to be greater than 8 feet. Where saturated, the overburden defines an upper aquifer and fractured bedrock- a lower, or deeper, aquifer. The transition from the overburden aquifer, where it is present, to the bedrock aquifer is marked by a weathered bedrock zone of variable thickness (ranging from 0 feet to approximately 20 feet). Data generated during the RI indicate that there is limited hydraulic communication between the overburden and bedrock aquifers beyond the immediate vicinity of the underground mine workings because of the poor vertical permeability and transmissivity of the crystalline bedrock.

Groundwater occurs in the overburden under unconfined, water table conditions in the PMP Area and the OCDA. Although saturated overburden has not been encountered in the CMP Area because of insufficient overburden thickness, groundwater occurs in the bedrock aquifer beneath the entire Site, including within the CMP Area. The overburden aquifer is monitored in two zones, the upper water table and the lower, or deeper, overburden. The bedrock aquifer is monitored in multiple zones ranging from tens of feet in depth to approximately 500 feet bgs. Based on monitoring well yield during the more than 25 years of groundwater sampling at the Site, the hydraulic conductivity of the overburden aquifer is low to moderate and is low to very low in the bedrock aquifer.

In the PMP and CMP Areas, the abandoned underground mine workings have filled with groundwater and, therefore, represent significant storage of groundwater with the volumes of stored water estimated at 213,000,000 gallons and 49,000,000 gallons, respectively (Getz 1965). Based on the very low historical mine dewatering rates (less than 54 and 33 gallons per minute, for the PMP and CMP Areas, respectively) and low to very low monitoring well yields during purging and sampling, the significant storage of groundwater within the abandoned mine workings does not appear to contribute to or increase the overall local hydraulic transmissivity, or groundwater movement, within the massive crystalline bedrock. Moreover, this large volume of groundwater storage and lack of yield from the area-specific monitoring wells indicates that fractures within the crystalline bedrock have very limited transmissivity and/or connectivity. The historical image to the right, of former mine workings, shows the massiveness of the rock and mine tunnels and illustrates that the tunnels are dry and the bedrock is not visibly fractured. The depth to groundwater in the overburden fluctuates seasonally and is typically deeper during dryer summer months with some wells being dry, or nearly dry, during drought conditions.

Historical photo of mine workings.

The direction of groundwater flow in both the overburden and bedrock aquifers is generally to the southeast. Groundwater ultimately discharges to streams, creating base flow in the perennial streams. As shown on Figure 2, surface water within the streams ultimately discharges into the Wanaque Reservoir, located approximately 1 mile from the confluence of Park Brook, North Brook, Mine Brook, and Ringwood Creek (WCC 1988).

Although groundwater at the Site is classified as Class IIA, a potential potable water source by NJDEP, groundwater at the Site is *not* used as a potable water source, and drinking water for the nearby residents is provided by four water production wells maintained by the Borough of Ringwood.

### 2.4 Conceptual Site Model Summary and RIR Conclusions

As described in the draft January 2015 GW RIR (ARCADIS 2015), the investigation activities completed between 2005 and 2014 were used to characterize residual conditions and supplement historical data to develop a Site-wide Conceptual Site Model that provides the framework for describing the nature, extent, fate, and transport of key Site constituents, including benzene, lead, and arsenic, as described in the conclusions presented below:

- Extensive investigatory work conducted since 2005 is consistent with, and supports, the conclusions drawn based on the groundwater investigations conducted during the 1980s and 1990s.

- The comprehensive monitoring well network and surface water sampling locations, coupled with the geologic, hydrogeologic, geochemical, and environmental data accumulated over the last 30 years of RI activities at the Site, have enabled the effective characterization of the nature and extent of Site-related constituents in groundwater and a complete understanding of Site-wide groundwater flow pathways.

- Groundwater sampling shows that concentrations of the constituents are low and limited in extent. Benzene is localized to the PMP Area; arsenic is primarily detected in the PMP Area and OCDA; and lead is sporadically detected in the PMP Area, OCDA, and CMP Area.

- Constituents are not detected in surface water beyond the Site boundaries. Benzene is localized in the SR-3 seeps and the Cannon/Diamond Seep, and arsenic and lead are periodically reported in the four streams at the Site, including upstream of the land ACs, but not at the downstream confluence with Ringwood Creek.

- Concentration trend analysis indicates benzene concentrations in groundwater in the PMP Area are generally decreasing, likely due to ongoing natural attenuation, including microbial degradation which has been shown to occur under existing groundwater conditions at the Site. The 2013 and 2014 groundwater results are generally consistent with the extensive historical groundwater analytical database for the Site--data outliers from PMP Area wells SC-01 and RW-6A withstanding--but some temporal variability is to be expected and the data indicate no other outlier data in adjacent or downgradient locations. In the PMP Area where the groundwater flow pathway has been documented using natural environmental tracers, groundwater discharges to Park Brook but benzene is not detected in Park Brook surface water and the discharge pathway is therefore incomplete.

- Arsenic and lead are detected sporadically in groundwater with many of the historic concentrations reported in groundwater reflective in whole or in part of elevated groundwater sample turbidity but, where arsenic and/or lead occur in groundwater at levels above the groundwater quality standards**,** they likely exist as insoluble oxide compounds. Concentrations readily decrease due to natural attenuation processes, including the presence of oxidized groundwater conditions beyond the reducing zone in the immediate vicinity of the PMP and OCDA land ACs.

- There is minimal bedrock flow in deep bedrock, but there is upward movement of groundwater from the bedrock along the preferential flow pathway created by the manmade underground mine workings in the PMP and CMP Areas as well as flow in shallow bedrock that discharges to the four onsite streams that flow to Ringwood Creek and eventually to the Wanaque Reservoir. RI data collected over the past 30 years confirm that, although groundwater discharges to surface waters at the Site, the constituents associated with the Site are not transported in groundwater or to surface water beyond the Site boundaries and there are no offsite impacts to groundwater or surface water, including the Wanaque Reservoir.

Similarly, there are no impacts to Ringwood’s municipal water supply wells located approximately 2 miles farther downgradient and in a separate watershed from the PMP Area and the Site.

## 3. Current Land Use

Current land use at the Site (excluding the embedded residential parcels) includes the Borough of Ringwood facilities (Department of Public Works yard and Recycling Center), State of New Jersey parkland (Ringwood Manor section of Ringwood State Park), utility corridors (PSE&G and Orange and Rockland Electric Company) that include a power substation, and open space (Borough of Ringwood property). Future development of open space at the Site is not likely because of conservation zoning, the presence of unbuildable slopes and wetlands, former landfills, extensive mine tailings deposits, and potential physical mine hazards (former pits and shafts).

Public drinking water is supplied to residents in the Borough of Ringwood from well fields located within a different watershed approximately 2 miles southeast of the Site. A secondary source of public drinking water is supplied from the Wanaque Reservoir, located approximately 0.5 mile southeast of the southernmost boundary of the Site. Groundwater and surface water are not used for potable purposes, and future use is unlikely given the high naturally occurring hardness, including elevated iron and manganese concentrations found in groundwater in historically mined areas, as well as at upgradient, background well locations. Low groundwater volumes and yield of the overburden and bedrock aquifers at the Site also contribute to the unlikelihood of development as a potable water source.

Paved roads at the Site are traveled by residents, mail carriers, delivery trucks, garbage and refuse haulers, utility workers, and visitors. The Recycling Center is open to the public on Wednesdays. Utility workers are periodically on site to clear brush in the utility corridors and to perform maintenance on the power transmission towers and at the substation.

Known recreational uses of the land include hiking in Ringwood State Park, hunting, and riding all-terrain vehicles. Although there is a pond at the PMP Area, a water-filled former concrete fire-water reservoir, and several ponds created by beaver dams, fishing has not been observed. Swimming is also an unlikely activity given the presence of dead tree snags, tree stumps, and/or debris in these areas, and/or inaccessibility due to the presence of heavy vegetation during the warmer months.

Areas of the Site where removal actions have occurred and the former landfill areas (PMP, CMP, and OCDA) are typically inaccessible during warmer months because of heavy vegetation at ground level (shrubs, vines, and briars). Restoration of these areas in the future will result in similar re-vegetation. Areas of sedimentation at the Site are typically inaccessible because of ponded water or swampy ground.

## 4. Summary of Available Groundwater Data and Data Analysis

The groundwater data representative of current Site conditions consist of 486 groundwater samples collected from 37 monitoring wells on the Site between April 28, 2008 and October 9, 2014. These samples were analyzed for VOCs and SVOCs including polycyclic aromatic hydrocarbons, and polychlorinated biphenyls, and metals. Additionally, select groundwater samples collected in 2008 were analyzed for pesticides but since they were not detected, pesticides were removed from sampling program with agency approval. Table 2.1 presents the summary statistics for compounds detected in at least one groundwater sample collected between 2008 and 2014 from monitoring wells representing Site-related groundwater.

Multiple remedial activities occurred at the Site between 1987 and 2014 and, therefore, some of the historical groundwater data do not reflect current Site conditions. Consequently, to characterize current conditions at the Site, the groundwater data presented include data collected from 2008 to 2014. If no further remedial actions are conducted at the Site, groundwater concentrations will continue to decrease from natural attenuation. Therefore, current groundwater concentrations are conservative estimates of future Site-related groundwater exposure concentrations.

Two upgradient wells, OB-01 and RW-01, were conservatively excluded from this BHHRA because they are not representative of potential impacts from the Site. Additionally, as agreed upon with USEPA on a conference call February 20, 2013 and verified in an email on February 22, 2013 to USEPA Region 2, water in both the PMP Area air shaft and the CMP Area shaft as described in detail in the GW RIR has been found to have very limited hydraulic connectivity with overburden and bedrock resulting in negligible mixing of mine pool water and downgradient groundwater. Therefore, results of samples collected from these mine shafts are not included in this BHHRA.

## 5. Human Health Evaluation

This BHHRA is an integral part of the environmental study of the Site and is designed to assist risk managers in making informed decisions regarding potential actions necessary to address hazardous substances. This BHHRA focuses on possible human health impacts associated with potential exposure to Ford-related constituents present in Site-related groundwater. Concentrations of COPCs detected in Site-related groundwater are combined with assumptions about the ways that people may be exposed to that medium to estimate potential Site-related risks. These risks are then compared to USEPA's acceptable risk range and target hazard index to determine if there is a potential for unacceptable health risks to occur as a result of exposure to Site-related groundwater.

This BHHRA was prepared via an iterative process, where specific assumptions and procedures were discussed with and approved by USEPA prior to the completion of the assessment. Initial BHHRA assumptions were reviewed with USEPA via a conference call on February 20, 2013, and then verified via email on February 22, 2013 (to Mr. Joseph Gowers and Mr. Michael Sivak of USEPA Region 2). As agreed, ARCADIS then submitted BHHRA Tables 0 through 4.1.RME to Mr. Joseph Gowers for agency review on May 5, 2013. USEPA Region 2 comments on these tables (issued on July 30, 2013) have been incorporated in this BHHRA.

### 5.1 Identification of Constituents of Potential Concern

The selection of COPCs in Site-related groundwater for evaluation in this BHHRA was conducted in two phases. First, any compound detected at a frequency less than 5% was excluded from further analysis in this BHHRA. For those compounds detected at a frequency greater than 5%, the maximum detected concentrations of each were compared with risk-based screening criteria to identify COPCs. As requested by USEPA Region 2, all Class A (known) human carcinogens were retained as COPCs regardless of their detection frequency or the comparison to risk-based screening concentrations. The COPC screening step is presented in Table 2.1 for Site-related groundwater.

For the Site-related COPC screening of groundwater samples, maximum detected concentrations were compared to USEPA's Regional Screening Levels (RSLs) for tap water (USEPA 2014a). These risk-based criteria are defined to be protective of drinking water exposures to adult and child residents. The RSLs are based on default USEPA exposure parameters and factors that represent RME conditions for long-term/chronic exposures. The RSLs that are based on cancer endpoints were derived based on a $1x10^{-6}$ target cancer risk limit. The RSLs that are based on effects other than cancer (noncarcinogenic effects) were derived by USEPA based on a hazard quotient of 1 and adjusted downward by a factor of 10 for use in this assessment.

If the maximum detected concentration exceeded the compound-specific tap water RSL, that compound was retained as a Site-related COPC. The COPC selection criteria and rationale for selection or exclusion as a COPC are provided in Table 2.1. The list of COPCs in Site-related groundwater includes VOCs, SVOCs, and metals. All three constituents determined to be primary constituents of concerns for Site-related groundwater in the GW RIR (ARCADIS 2015), benzene, lead, and arsenic, were retained as COPCs in this BHHRA.

### 5.2 Exposure Assessment

This BHHRA was developed following USEPA guidance and policy. Exposure scenarios were developed and exposure parameters were identified using a variety of sources, including USEPA's Exposure Factors Handbook (USEPA 2011), and, when appropriate, best professional judgment. As detailed in the following subsections, RME and CT exposure scenarios were developed for the Site-related groundwater exposure scenarios evaluated in this BHHRA, which include potential future use of groundwater by a hypothetical future resident even though groundwater at the Site is not used for drinking water or for domestic use and it is highly unlikely that it would be in the future[2].

Note that the RME scenario is defined by USEPA as the highest exposure that is reasonably expected to occur at a site and is intended to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures (USEPA 1989). The CT exposure scenario is defined by USEPA as representing the average or typical individual in a population, usually the mean or median of the distribution (USEPA 1989).

[2] As stated above, groundwater is not used for potable purposes, and future use for domestic purposes is unlikely given the high naturally occurring hardness, including elevated iron and manganese concentrations found in groundwater which create objectionable odor, color, and taste as well as the low yield of water volumes (ARCADIS 2015).

### 5.2.1 Exposure Pathways and Populations

The hypothetical future resident scenario was evaluated for potential exposure to Site-related groundwater if used as a potable source of water because NJDEP has classified the aquifers at the Site as Class IIA. The specific assumptions and parameters used to evaluate this hypothetical scenario are discussed in the following sections. The uncertainties associated with those assumptions and their potential impacts on the resulting risk estimates are discussed in detail in the Uncertainty Analysis in Section 5.4.2.

A portion of the Site is zoned for residential use and, as previously stated, the State of New Jersey classifies the aquifers at the Site as Class IIA, meaning that groundwater could theoretically be used for potable purposes. Currently, all residences at and in the vicinity of the Site are connected to a municipal water source and, as previously stated, it is unlikely that Site-related groundwater would ever be used as potable water. However, because potable use is not currently prohibited, under future potential use, a hypothetical future resident is assumed to be exposed to Site-related groundwater via ingestion as drinking water as well as via inhalation and dermal contact while showering or bathing.

Three age categories were evaluated for the hypothetical resident scenario: an adult between the ages of 17 and 30 years, an older child or youth between the ages of 7 and 16 years, and a young child between the ages of 1 and 6 years. Tables 4.1.CT and 4.1.RME provide the exposure assumptions used to evaluate potential exposures for the hypothetical future resident scenario for each of these age categories.

Under both the RME and CT exposure scenarios, it is assumed that the hypothetical future resident is exposed to groundwater 350 days/year for each age category under a future use scenario. As required by USEPA for the RME analysis in land-based HHRAs (PMP Area, CMP Area, and OCDA), the hypothetical resident was assumed to be exposed in the future over a total exposure duration of 52 years (including 6 years as a young child, 10 years as an older child, and 36 years as an adult). For the CT exposure scenario, the exposure duration is 9 years (6 years as a young child and 3 years as an older child) based on the average total residence time (12 years) in the United States (USEPA 1997).

Under the RME scenarios, drinking water ingestion rates of 2, 2, and 1 liter per day (L/day) were used to evaluate potential future exposures by a hypothetical resident receptor as an adult, an older child, and a young child, respectively. For the CT exposure scenarios, a drinking water ingestion rate of 0.33 L/day was used to evaluate potential future exposure by the young child, a rate of 0.48 L/day was used to evaluate potential future exposure by an older child, and a rate of 1 L/day was used to evaluate potential exposure by an adult based on CT estimates provided in USEPA's Exposure Factors Handbook (USEPA 2011).

The hypothetical future resident is also assumed to be exposed to COPCs in groundwater while showering. Under both RME and CT exposure scenarios, it is assumed that the skin surface area for the entire body is exposed while showering. RME exposure time is assumed to be 0.67 hours/shower event for the adult, 0.52 hours/shower event for the older child, and 0.50 hours/shower event for the young child. Under the CT exposure scenario, it is assumed the exposure time is 0.33 hours/event for the adult, 0.30 hours/event for the older child, and 0.31 hours/event for the young child (USEPA 2011).

The hypothetical future resident is also assumed to be exposed to volatile COPCs via inhalation while showering. The exposure time for the inhalation route assumes the receptor is breathing volatile COPCs both during the shower and for a period of time in the bathroom after the shower. Thus, the exposure period for the inhalation exposure pathway is assumed to be longer than the exposure period for water via the dermal contact pathway. Under the RME scenario, the exposure time is assumed to be 0.92 hours/event for the adult, 0.79 hours/event for the older child, and 0.72 hours/event for the young child. Under the CT exposure scenario, it is assumed the exposure time is 0.47 hours/event for the adult, 0.42 hours/event for the older child, and 0.43 hours/event for the young child (USEPA 2011).

For both the RME and CT exposure scenarios, the exposure assumptions for each of the age group categories for the hypothetical future resident scenario are presented in Tables 4.1.CT and 4.1.RME, respectively.

#### 5.2.2 Determination of Exposure Point Concentrations

USEPA's ProUCL software (version 5.0; USEPA 2013a) was used to derive exposure point concentrations (EPCs). In accordance with discussions with USEPA Region 2, the 95$^{th}$ percentile upper confidence limits on the arithmetic mean (95$^{th}$ UCL) were selected as EPCs except when the 95$^{th}$ UCL exceeded the maximum concentration detected. In that case, the maximum concentration was selected as the EPC. For the purposes of this BHHRA, all groundwater samples collected at the Site were assumed to be representative of groundwater quality. Therefore, no spatial or temporal averaging was performed on the dataset before calculating the 95$^{th}$ UCL. Table 3.1 presents the EPCs for groundwater. The ProUCL Output is provided in Appendix A.

*5.2.2.1 Groundwater EPCs*

A total of 486 groundwater samples were collected from 37 wells on the Site between April 28, 2008 and October 9, 2014. The 95$^{th}$ UCLs were calculated using USEPA's ProUCL software (version 5.0; USEPA 2013a). Recommended 95$^{th}$ UCLs were compared to the maximum detected concentrations for each COPC and the lower of the two concentrations was chosen as the EPC, with the exception of lead. For lead, the average concentration was chosen as the EPC in accordance with USEPA lead modeling guidance (USEPA 1994 and 2003). Table 3.1 presents the EPCs for Site-related groundwater.

*5.2.2.2 Shower Air EPCs*

As required by USEPA Region 2, inhalation exposure to volatile COPCs in tap water during a shower was defined as a potential exposure pathway. The shower air EPCs were calculated using the Schaum shower model (Schaum et al. 1994). This shower model estimates the amount of a volatile compound that is released and/or volatilizes into the air of a single shower room compartment during showering. The model incorporates information about showering conditions and individual activity patterns.

The Schaum shower model equations used to estimate the shower air EPCs for the volatile COPCs in Site-related groundwater are presented below:

$$CA = \frac{(CA_{max} / 2) \times t_1 + CA_{max} \times t_2}{t_1 + t_2}$$

where:

| | | |
|---|---|---|
| CA | = | Constituent concentration in air (micrograms per cubic meter [µg/m$^3$]) |
| $CA_{max}$ | = | Maximum concentration of constituent in air (µg/m$^3$) |
| $t_1$ | = | Time in shower (hours) |
| $t_2$ | = | Time in room after shower (hours) |

$$CA_{max} = \frac{C_w \times f \times F_w \times t_1}{V_a}$$

where:

| | | |
|---|---|---|
| $CA_{max}$ | = | Maximum concentration of COPC in air (µg/m$^3$) |
| $C_W$ | = | COPC concentration in water (micrograms per liter [µg/L]) |
| f | = | Fraction volatilized (unitless) |
| $F_W$ | = | Shower water flow rate (L/hour) |
| $t_1$ | = | Time in shower (hours) |
| $V_a$ | = | Bathroom air volume (cubic meter [m$^3$]) |

For COPCs with unknown fraction volatilized ($f_i$):

$$f_i = f_j \times \frac{(2.5 / D_w^{0.67} + R \times T / D_a^{0.67} \times H)_j}{(2.5 / D_w^{0.67} + R \times T / D_a^{0.67} \times H)_i}$$

where:

| | | |
|---|---|---|
| $f_i$ | = | Fraction volatilized for constituent i (unitless), constituent-specific |
| $f_j$ | = | Fraction volatilized for constituent j (unitless), constituent-specific |
| $D_w$ | = | Diffusivity in water (square meters [m$^2$]/second), constituent-specific |
| $D_a$ | = | Diffusivity in air (m$^2$/second), constituent-specific |
| R | = | Gas constant (atm-m$^3$/mol-K) |
| T | = | Temperature (K) |
| H | = | Henry's law constant (atm-m$^3$/mol), constituent-specific |

Appendix B presents the calculation of shower air concentrations from the groundwater EPCs. Table 3.2 presents the EPCs for shower air.

### 5.2.3 Estimation of Chemical Intake

The Chronic Daily Intake (CDI) was calculated to estimate a receptor's potential daily intake from exposure to constituents in the medium of interest. The equations used to estimate CDIs are presented below. The human exposure parameters used in each potential exposure pathway for the CT and the RME exposure scenarios are presented in Tables 4.1 CT and 4.1 RME, respectively.

As described in Section 5.2.1, potential exposure to groundwater as a future source of potable water is assumed to occur via ingestion, dermal contact, and inhalation of volatile compounds while showering. For each COPC, the estimate of the CDI associated with drinking water ingestion is calculated as follows:

$$CDI = \frac{C_{GW} \times IR \times EF \times ED \times CF}{AT \times BW}$$

where:

CDI = Chronic daily intake due to ingestion (milligrams per kilogram per day [mg/kg-day])
$C_{GW}$ = Chemical concentration in groundwater (µg/L)
IR = Ingestion rate of drinking water (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor ($10^{-3}$ milligrams per micrograms [mg/µg])
BW = Body weight (kilograms [kg])
AT = Averaging time (days)

For each COPC, the estimate of the CDI associated with dermal contact with constituents in groundwater used as a potential source of tap water is calculated as follows:

$$CDI = \frac{DA_{event} \times EV \times ED \times EF \times SA}{AT \times BW}$$

where:

CDI = Chronic Daily Intake due to dermal contact (mg/kg-day)
$DA_{event}$ = Absorbed dose per event (milligrams per square centimeter per event [mg/cm$^2$]-event)
EV = Event frequency (events/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SA = Skin surface area available for contact (square centimeters [cm$^2$])
BW = Body weight (kg)
AT = Averaging time (days)

For organic compounds, the absorbed dose per event (or $DA_{event}$) is calculated using either of the two following equations selected based on the ratio of the event duration ($t_{event}$) relative to the time for the compound of interest to reach steady state (t*).

If $t_{event} \leq t^*$, then $DA_{event}$ is calculated as follows:

$$DA_{event} = 2FA \times K_p \times C_{GW} \times CF \times \sqrt{\frac{6T \times t_{event}}{\Pi}}$$

If $t_{event} > t^*$, then $DA_{event}$ is calculated as follows:

$$DA_{event} = FA \times K_p \times C_{GW} \times CF \times \left[\frac{t_{event}}{1+B} + 2T_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

where:

| | | |
|---|---|---|
| $DA_{event}$ | = | Absorbed dose per event (mg/cm$^2$-event) |
| FA | = | Fraction absorbed of water (unitless) |
| $K_p$ | = | Dermal permeability coefficient of compound in water (centimeters per hour [cm/hour]) |
| $C_{GW}$ | = | EPC of COPC in groundwater (µg/L) |
| CF | = | Conversion factor ($10^{-3}$ liters per cubic centimeter [L/cm$^3$] x $10^{-3}$ mg/µg) |
| $T_{event}$ | = | Lag time per event (hours/event) |
| $t_{event}$ | = | Event duration (hours/event) |
| t* | = | Time to reach steady-state (hours) = 2.4 $T_{event}$ if B ≤ 0.6 |
| B | = | Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the epidermis (unitless) |

For inorganic COPCs, $DA_{event}$ is calculated using the following equation:

$$DA_{event} = K_p \times C_{GW} \times CF \text{ x } ET$$

where:

| | | |
|---|---|---|
| $DA_{event}$ | = | Absorbed dose (mg/cm$^2$-event) |
| $K_p$ | = | Dermal permeability coefficient of compound in water (cm/hour) |
| $C_{GW}$ | = | EPC of COPC in groundwater (µg/L) |
| CF | = | Conversion factor ($10^{-3}$ L/cm$^3$ x $10^{-3}$ mg/µg) |
| ET | = | Exposure time (hours/event) |

As required by USEPA Region 2, potential exposure to volatile COPCs via inhalation of shower air was estimated using the Schaum model (Schaum et al. 1994) (see Section 5.2.2.2). For each volatile COPC in groundwater, the estimate of the CDIs for the inhalation of volatile compounds while showering was calculated as follows:

$$CDI = \frac{CA \times ET \times EvF \times EF \times ED}{AT}$$

where:

| | | |
|---|---|---|
| CDI | = | Chronic Daily Intake due to inhalation of volatile compounds while showering (µg/m$^3$) |
| CA | = | Chemical concentration in air (µg/m$^3$); estimated using Schaum model (see Section 5.2.2.2) |
| ET | = | Exposure time (hours/event) |
| EvF | = | Event frequency (events/day) |
| EF | = | Exposure frequency (days/year) |
| ED | = | Exposure duration (years) |
| AT | = | Averaging time (hours) |

### 5.3 Toxicity Assessment and Risk Characterization

The Toxicity Assessment step involves quantifying the relationship between the magnitude of potential exposure to COPCs via a particular exposure pathway and the likelihood of an adverse health effect. Adverse health effects are characterized by USEPA as carcinogenic and/or non-carcinogenic effects. Dose-response relationships are defined by USEPA for oral and inhalation routes of exposure. The results of the Toxicity Assessment, when combined with the dose estimated in the Exposure Assessment, are used to estimate both potential cancer and non-cancer health risks.

Tables 5.1 and 5.2 present the non-cancer toxicity values used in this BHHRA, and Tables 6.1 and 6.2 present the cancer toxicity values used in this BHHRA. Toxicity values are developed by USEPA, state regulatory agencies, and other entities after a scientific review of all available toxicological literature and dose-response information for a constituent. The toxicity values used in this BHHRA for all COPCs (with the exception of lead) were obtained from the following sources, in order of priority, in accordance with USEPA guidance (USEPA 2003):

- Tier 1 – USEPA's Integrated Risk Information System (USEPA 2014b)
- Tier 2 - USEPA's Provisional Peer Review Toxicity Values (USEPA 2014c)
- Tier 3 – Other toxicity values including those from additional USEPA and non-USEPA sources such as USEPA's Health Effects Assessment Summary Tables (USEPA 1997), and values developed by the Agency for Toxic

Substances and Disease Registry and the California Environmental Protection Agency

As requested by USEPA, age-dependent adjustment factors were applied to carcinogenic COPCs defined by USEPA to act via a mutagenic mode of action in accordance with USEPA (2005) guidance. Potentially mutagenic COPCs in Site-related groundwater include trichloroethene and chromium, assumed for purposes of this evaluation to be hexavalent chromium. Appendix C presents the calculation of the age-dependent adjustment factors for the mutagenic compounds in Site-related groundwater.

As shown in Appendix C, an adjustment factor of 10 for one year of exposure and 3 for the remaining five years of exposure is applied to the oral/dermal slope factor and inhalation unit risk for the young child. An adjustment factor of 3 is applied to the oral/dermal slope factor and inhalation unit risk for the older child. The adjustment is mechanically easier if the intake is adjusted instead of the toxicity factors. Therefore, the CDI for the youth receptor (age 7 to 16 years) was multiplied by a factor of 3 to estimate the intake of trichloroethene and chromium. For the young child receptor, the CDI was multiplied by a factor of 10 to estimate the intake of trichloroethene and chromium from ages 1 to 2 years and a factor of 3 to estimate the intake of trichloroethene and chromium from ages 2 to 6. Appendix C presents the age-dependent calculations for mutagenic compounds.

### 5.3.1 Lead Toxicity Assessment

The potential for adverse health effects from exposure to lead were evaluated based on current USEPA guidance (USEPA 2003, 2007, 2009). The potential hazard due to lead exposures by the hypothetical young child resident was evaluated using USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (USEPA 2010). Lead exposure for the adult and older child was evaluated using the Adult Lead Model (ALM) (USEPA 2001), which addresses only soil exposure. Therefore, potential risks from lead exposures through groundwater as potable drinking water could not be assessed for the adult and older child.

The IEUBK model takes into account default intake and uptake components of lead exposure using Site-specific data to predict concentration(s) of lead in blood (blood lead levels). The basis of the model is that blood lead levels are predictive of the potential for adverse health effects, with the most sensitive target currently identified as the nervous system in a young child (age 6 to 84 months).

The IEUBK model is a biokinetic model that allows one to calculate blood lead levels in a young child who has potentially been exposed to lead at background levels as well as from lead in a variety of media, including drinking water and diet. The IEUBK model output provides an estimate of the percentage of the exposed population that would have blood levels that exceed USEPA's "safe" level of lead in blood, 10 micrograms per deciliter (µg/dL). It is USEPA's current policy that potential exposures to lead are deemed to be acceptable as long as no more than 5% of the exposed population will exceed that regulatory benchmark of blood lead level of 10 µg/dL.

### 5.4 Risk Characterization

The Risk Characterization combines the results of the exposure assessment and the toxicity assessment to provide a quantitative estimate of the potential risks associated with exposure to Site-related COPCs in groundwater. Consistent with USEPA guidance (1989), the potential for carcinogenic risks and non-carcinogenic health hazards are evaluated separately. Conservative estimates of cancer and non-cancer risks for all receptors potentially exposed to the COPCs detected in Site-related groundwater are presented below.

The estimates of potential cancer risk are compared to USEPA's acceptable cancer risk range of $1x10^{-6}$ to $1x10^{-4}$, and for non-cancer effects, the estimated hazards are compared to a hazard index limit of 1 to determine whether the estimated potential future risks exceed those benchmarks and thus may present an unacceptable level of risk. A summary of the potential cancer risks and hazard indices by age categories for the hypothetical future resident receptor under the RME and CT exposure scenarios are presented in Tables 11.1.RME and 11.1.CT, respectively.

#### 5.4.1 Hypothetical Future Resident Scenario

The cumulative potential cancer risk for the hypothetical future resident RME scenario for the adult, young child, and older child is $1x10^{-4}$, which is at the upper end of USEPA's acceptable risk range. The total non-cancer hazard index for the hypothetical future resident RME exposure scenario for the adult, older child and young child RME scenarios are 2, 3, and 4, respectively. However, when the hazard index is assessed by target organ for the future hypothetical resident RME scenario for the adult, the older child, and the young child, all target organ hazard indices are below the USEPA's target hazard index of 1. Tables 7.1.RME, 7.2.RME, and 7.3.RME present the potential cancer and non-cancer risks for the adult, older child, and young child hypothetical future resident, respectively. Tables 9.1.RME, 9.2.RME, and

9.3.RME present the potential cancer and non-cancer risks assessed by target organ for the adult, older child, and young child resident, respectively. Table 11.1.RME presents the cumulative potential cancer risk and summary of potential non-cancer risks.

Available lead models do not estimate potential risks to adults via water ingestion. Therefore, blood lead levels were only estimated for the young child. Estimated blood lead levels following potential exposure to lead in Site-related groundwater for a young child resident under an RME scenario are predicted to exceed 10 µg/dL in 0.079% of the hypothetically exposed population, which is below USEPA's target threshold of 5%. Table 12.1.RME presents the results of the IEUBK model for the young child resident.

The cumulative potential cancer risk for the hypothetical future resident CT exposure scenario for the young child and older child is $1x10^{-5}$, which is within USEPA's acceptable risk range. The potential non-cancer risk for the hypothetical future resident CT exposure scenario for the older child is 0.6, which is below USEPA's target hazard index. The potential non-cancer risk for the hypothetical future resident CT exposure scenario for the young child is 1, which is at USEPA's target hazard index. Tables 7.2.CT and 7.3.CT present the potential cancer and non-cancer risks for the older child and young child resident, respectively. Tables 9.2.CT and 9.3.CT present the potential cancer and non-cancer risks assessed by target organ for the older child and young child resident, respectively. Table 11.1.CT presents the cumulative potential cancer risk and summary of potential non-cancer risks.

Estimated blood lead levels following potential exposure to lead in Site-related groundwater for a young child resident under a CT exposure scenario are predicted to exceed 10 µg/dL in less than 0.040% of the hypothetically exposed population, which is significantly below USEPA's target threshold of 5%. Table 12.1.CT presents the results of the IEUBK model for the young child resident.

As required by USEPA, even when carcinogenic and non-carcinogenic risk estimates are within or below USEPA benchmarks, USEPA risk management decisions will follow guidance as outlined in USEPA 1991; "Chemical specific standard that define acceptable risk levels (e.g., non-zero MCLs, MCLs) also may be used to determine whether an exposure is associated with an unacceptable risk to human health or the environment and whether remedial action under Section 104 or 106 is warranted. For ground water actions, MCLs and non-zero MCLGs will generally be used to gauge whether remedial action is warranted."

### 5.4.2 Uncertainty Analysis

The risk characterization also includes an evaluation of the potential uncertainties associated with this BHHRA. Various sources of uncertainty are inherent in the risk assessment process. These sources can include uncertainties associated with, but not limited to, exposure factors, EPCs, toxicity factors, and/or modeling. The objective of an uncertainty analysis is to present key information regarding assumptions and uncertainties in the risk assessment process to place the quantitative risk estimates in proper perspective (USEPA 1989).

#### *5.4.2.1 Identification of COPCs*

COPCs at the Site were identified using a conservative risk-based screening process resulting in a high degree of confidence that no constituents that may contribute significantly to total potential risks would be eliminated from the risk assessment and to ensure the risk assessment focused on those constituents that could potentially pose a significant risk. The screening process used the maximum detected concentrations in the data representing groundwater samples collected between 2008 and 2014 from the existing groundwater monitoring wells installed at the Site to characterize groundwater quality within each of the three land ACs as well as upgradient and downgradient areas of the Site.

The maximum concentrations of COPCs reported in groundwater were compared to conservative risk-based screening values that were derived using conservative assumptions of potential exposure. Additionally, screening values based on non-cancer endpoints were divided by a factor of 10 to account for potential additive effects.

#### *5.4.2.2 Exposure Assessment*

As stated previously, the groundwater at the Site is not currently being used as drinking water or for domestic purposes and it is highly unlikely to be used as such in the future based on the naturally occurring concentrations of iron and manganese and the low yield of the aquifers at the Site. Highly conservative exposure assumptions were therefore incorporated in this BHHRA that likely overestimate potential risks.

As required by USEPA Region 2, the Schaum model (Schaum et al. 1994) was used to estimate exposure to volatile groundwater COPCs in air via inhalation while showering. No supporting studies have been conducted to validate the air exposures estimated using this model. The model estimates chemical releases into the air of a single shower room compartment during showering and incorporates information on showering conditions and individual activity patterns. The model uses a transfer efficiency parameter to model chemical concentrations released into air. It is a relatively simple model with several suggested default inputs; therefore, its utility is highest for screening-level assessments and other situations in which little site-specific information is available.

The model tends to overestimate air exposures for compounds of lower volatility. Furthermore, the model does not consider the effects of air exchange on exposure concentrations, and thereby is another source of overestimating air exposures. The model is sensitive to shower flow rate, shower volume, and exposure time and insensitive to water temperature. It assumes that volatile compounds are released to the air at a constant rate regardless of the potential for a steady-state condition to occur between the air and the shower water. It is therefore likely that this model overestimates the concentration of COPCs in shower air.

Note that total chromium concentrations in groundwater at the Site were not speciated between hexavalent chromium and trivalent chromium because the entrations are all well below both the NJDEP Groundwater Quality Standards and USEPA Maximum Contaminant Levels. For purposes of this BHHRA, in the absence of speciation data, the concentrations of total chromium were conservatively assumed to be 100% hexavalent chromium. USEPA is currently re-assessing the potential carcinogenic effect of hexavalent chromium via the ingestion route because hexavalent chromium has been shown to be reduced to trivalent chromium in the gastrointestinal tract (USEPA 2013b). Therefore, any potential risk from chromium concentrations in Site-related groundwater would clearly be overestimated.

*5.4.2.3 Exposure Point Concentrations*

The EPCs for all COPCs except lead have been selected as the $95^{th}$ UCL concentration in groundwater. This concentration overestimates the concentrations of constituents to which individuals would be exposed if groundwater at the Site were ever to be used for domestic use. This is particularly true for the Ringwood Mines/Landfill Site because the EPCs are based on groundwater data collected from areas affected by historic landfilling and disposition activities and thus sampling has been intentionally biased to collect data in areas that are suspected of having higher COPC concentrations. In fact, individuals who are present at the Site would hypothetically use groundwater as potable drinking water would have exposures to both impacted and non-impacted groundwater.

*5.4.2.4 Toxicity Assessment*

Toxicity values selected for use in this BHHRA have been intentionally developed using multiple safety and modifying factors to ensure that potential toxicity to humans is not underestimated. These factors are intentionally incorporated to consider inter-individual variability, interspecies differences in response, high-to-low dose extrapolation, and uncertainties associated with study designs. Therefore, their use overestimates potential risks associated with exposure to those compounds.

While the IEUBK model is capable of estimating potential risk to the young child from lead concentrations in all relevant media, the ALM is limited to lead concentrations in soil. Therefore, potential risks from lead reported in Site-related groundwater could not be calculated for the adult and older child hypothetical future resident scenarios. This limitation results in a potential underestimation of risks associated with lead concentrations in Site-related groundwater to the adult and older child hypothetical future resident.

*5.4.2.5 Risk Characterization*

Combining all of these factors into risk estimates presented in this BHHRA results in an overestimate of any potential exposure and any potential risk from that exposure.

## 6. Summary

While groundwater and surface water are not used as a source of potable water at the Site, and future uses for drinking or domestic purposes are unlikely given the high natural iron and manganese contents (which create objectionable odor, color, and taste) and the low yield of water volumes, this BHHRA for the Ringwood Superfund Site assumes that a hypothetical future resident could be exposed to COPCs in Site-related groundwater used as a future source of drinking water because groundwater at the Site has been classified as Class IIA by NJDEP, a potential potable water source. The hypothetical future resident is therefore assumed to be exposed to groundwater via ingestion as well as dermal contact and inhalation of volatile compounds during showering. In addition to this conservative assumption, conservative exposure estimates were used to estimate the exposure of the hypothetical future resident.

The potential cancer risks and non-cancer hazards estimated for the hypothetical future resident under both RME and CT exposure scenarios are within or below USEPA's benchmarks. All COPCs (as determined by the screening presented in Section 5.1) were retained for analysis in this BHHRA, including benzene, lead, and arsenic which were determined to be primary constituents of concerns for Site-related groundwater in the Site-Wide Groundwater Remedial Investigation Report (ARCADIS 2015). As determined by the evaluation conducted in this BHHRA, the potential cancer risks and non-cancer hazards estimated for the hypothetical future resident under both RME and CT exposure scenarios are within or below USEPA's benchmarks.

Even though the potential cancer risks and non-cancer hazards estimated for the hypothetical future resident under both RME and CT exposure scenarios are within or below USEPA's benchmarks, the estimated lifetime cancer risk for the hypothetical future resident is driven by arsenic and not benzene.

As described previously, there is a long history of disposal operations, including: Ford disposal of paint waste and other non-liquid plant wastes from 1967 until 1971, disposal of mine tailings from the 1700s through the 1950s, and dumping by others that occurred before, during, and after the four-year period that Ford-related wastes were disposed of at the Site. Sources of the COPCs–which includes arsenic-can be related to some or all of these disposal operations, and arsenic is also contributed by the natural occurring arsenic in the bedrock.

Specifically, analysis indicates that arsenic concentrations at the Site are dominated by naturally occurring minerals and mine tailings from historical mining activities, not residues from Ford-related paint waste (ARCADIS 2008c). In addition, as discussed in Section 4.6.6 of the GW RIR, the results of the RI indicate that elevated sample turbidity and interference from rare earth elements also contribute to the reported total and dissolved arsenic concentrations in groundwater resulting in levels that were likely biased high (ARCADIS 2015). Taken together, the RI data generated from all three of the land ACs and the Site-related Groundwater indicate that, given that naturally occurring iron ore is abundant at the Site and iron mine tailings are encountered at various locations at the Site and were present before any waste materials from Ford were disposed at the Site, the estimated lifetime cancer risk reported in this BHHRA is the background risk associated with the mineralogy of the area.

A sensitivity analysis was performed to evaluate the contribution of arsenic on the estimated lifetime cancer risk. When arsenic is removed as a COPC from the calculations, and risk is calculated with all other COPCs other than arsenic, the estimated lifetime cancer risk for the CT exposure scenario is lowered to $1x10^{-6}$ and the estimated lifetime cancer risk for the RME scenario is lowered to $1x10^{-5}$. Furthermore, if the minimum concentration of arsenic detected in groundwater at the Site is used as the EPC instead of the 95$^{th}$ UCL, the estimated lifetime cancer risk for the CT scenario is lowered to $5x10^{-6}$ and the estimated lifetime cancer risk for the RME scenario is lowered to $6x10^{-5}$. Thus, the analysis is very sensitive to even low concentrations of arsenic in hypothetical future drinking water and the fact that reported arsenic concentrations in groundwater are biased high due to turbidity as well as due to interference from rare earth elements (ARCADIS 2015). It is important to consider that even if reported concentrations are slightly biased high, it is still below USEPA's benchmark.

Potential exposures to lead concentrations in Site-related groundwater under both RME and CT exposure scenarios were evaluated using USEPA's IEUBK model for assessing lead exposures in a young child. This evaluation resulted in estimated blood lead levels that are below USEPA's current lead goal of no more than a 5% chance that any child will have a blood lead value above 10 µg/dL under both RME and CT exposure scenarios.

In conclusion, all potential cancer and non-cancer risks estimated in this BHHRA are within or below USEPA's benchmarks even with the very conservative estimates of potential exposure and potential risk that were utilized and the contributions from the natural mineralogy. Moreover, groundwater is not used at the Site and it is highly unlikely that groundwater will ever be a potable resource for drinking, showering or any use.

## 7. References

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# Tables

**Table 0**
**Site Risk Assessment Identification Information**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| **Site Name/Operable Unit:** | **Ringwood Mines/Landfill Superfund Site** |
|---|---|
| Region: | USEPA Region 2 |
| USEPA ID Number: | NJD980529739 |
| State: | New Jersey |
| Status: | |
| Federal Facility (Y/N): | |
| USEPA Project Manager: | Joseph Gowers |
| USEPA Risk Assessor: | Michael Sivak |
| Prepared by (Organization): | ARCADIS U.S., Inc. |
| Prepared for (Organization): | Ford Motor Company |
| Document Title: | Draft Site-Wide Groundwater Baseline Human Health Risk Assessment |
| Document Date: | March 2015 |
| Probabilistic Risk Assessment (Y/N): | No |
| Comments: | |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
USEPA = U.S. Environmental Protection Agency

**Table 1**
**Selection of Exposure Pathways**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|
| Current | Groundwater | Groundwater | Tap Water | Hypothetical Future Resident | Adult | Ingestion | None | Exposure pathways incomplete. Site groundwater is not currently used for domestic water supply. |
| | | | | | | Dermal (showering) | | |
| | | | | | | Inhalation (showering) | | |
| | | | | | Youth | Ingestion | | |
| | | | | | | Dermal (showering) | | |
| | | | | | | Inhalation (showering) | | |
| | | | | | Young Child | Ingestion | | |
| | | | | | | Dermal (showering) | | |
| | | | | | | Inhalation (showering) | | |
| Future | Groundwater | Groundwater | Tap Water | Hypothetical Future Resident | Adult | Ingestion | Quantitative | Exposure pathways potentially complete. USEPA requires that Class IIa groundwater be assessed for future potable use. |
| | | | | | | Dermal (showering) | | |
| | | | | | | Inhalation (showering) | | |
| | | | | | Youth | Ingestion | | |
| | | | | | | Dermal (showering) | | |
| | | | | | | Inhalation (showering) | | |
| | | | | | Young Child | Ingestion | | |
| | | | | | | Dermal (showering) | | |
| | | | | | | Inhalation (showering) | | |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
USEPA = U.S. Environmental Protection Agency

**Table 2.1**
**Occurrence, Distribution, and Selection of Constituents of Potential Concern**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | CAS Number | Chemical | Minimum Concentration (Qualifier) (1) | | Maximum Concentration (Qualifier) (1) | | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration Used for Screening (2) | Screening Toxicity Value (n/c) (3) | | Potential ARAR/TBC Value | Potential C Source (4) | COPC Flag (Y/N) | FOD | SL/TX | Rationale for Selection or Deletion (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tap Water | Volatile Organic Compounds (VOCs) | | | | | | | | | | | | | | | | | | |
| | 71-55-6 | 1,1,1-Trichloroethane | 1.2 | | 2.5 | | µg/L | OB-27(5/18/2011) | 2/455 | 0.2 to 0.32 | 2.5 | 800 | n | 200 | MCL | N | FOD | BSL | FOD,BSL |
| | 75-34-3 | 1,1-Dichloroethane | 0.23 | J | 89.3 | J | µg/L | OB-27(5/18/2011) | 60/455 | 0.16 to 0.35 | 89.3 | 2.7 | c | NA | | Y | | ASL | ASL |
| | 78-93-3 | 2-Butanone (MEK) | 3.4 | J | 27.7 | J | µg/L | RW-11D(11/14/2013) | 9/455 | 1.6 to 3.2 | 27.7 | 560 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 591-78-6 | 2-Hexanone | 1.7 | J | 2.1 | | µg/L | RW-2(6/29/2010) | 3/455 | 1.4 to 3 | 2.1 | 3.8 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 67-64-1 | Acetone | 5.9 | J | 95 | | µg/L | RW-2(6/29/2010) | 35/455 | 2.1 to 7.6 | 95 | 1400 | n | NA | | N | | BSL | BSL |
| | 71-43-2 | Benzene | 0.23 | J | 88.1 | | µg/L | RW-6A(9/5/2014) | 86/455 | 0.05 to 6 | 88.1 | 0.45 | c | 5 | MCL | Y | | ASL | ASL |
| | 75-27-4 | Bromodichloromethane | 0.37 | J | 0.6 | J | µg/L | RW-2(10/26/2009) | 3/455 | 0.14 to 0.28 | 0.6 | 0.13 | c | 80 | MCL | N | FOD | ASL | FOD |
| | 75-15-0 | Carbon disulfide | 0.27 | J | 55.7 | | µg/L | RW-3DS(11/12/2013) | 34/455 | 0.13 to 0.74 | 55.7 | 81 | n | NA | | N | | BSL | BSL |
| | 108-90-7 | Chlorobenzene | 0.22 | J | 2.3 | | µg/L | RW-2(9/26/2014) | 4/455 | 0.14 to 0.39 | 2.3 | 7.8 | n | 100 | MCL | N | FOD | BSL | FOD,BSL |
| | 75-00-3 | Chloroethane | 0.39 | J | 208 | | µg/L | OB-27(4/25/2012) | 63/455 | 0.22 to 0.56 | 208 | 2100 | n | NA | | N | | BSL | BSL |
| | 67-66-3 | Chloroform | 0.32 | J | 16.1 | | µg/L | RW-2(10/26/2009) | 17/455 | 0.14 to 0.25 | 16.1 | 0.22 | c | 80 | MCL | N | FOD | ASL | FOD |
| | 156-59-2 | cis-1,2-Dichloroethene | 0.29 | J | 0.6 | J | µg/L | OB-27(4/25/2012) | 9/455 | 0.19 to 0.33 | 0.6 | 3.6 | n | 70 | MCL | N | FOD | BSL | FOD,BSL |
| | 110-82-7 | Cyclohexane | 0.21 | J | 3.4 | J | µg/L | RW-6A(11/8/2013) | 29/455 | 0.18 to 1.9 | 3.4 | 1300 | n | NA | | N | | BSL | BSL |
| | 75-71-8 | Dichlorodifluoromethane | 0.97 | J | 2.7 | J | µg/L | SC-01(6/2/2010) | 2/455 | 0.31 to 0.92 | 2.7 | 20 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 100-41-4 | Ethylbenzene | 0.31 | J | 6.8 | | µg/L | SC-01(4/27/2012) | 17/455 | 0.21 to 0.4 | 6.8 | 1.5 | c | 700 | MCL | N | FOD | ASL | FOD |
| | 98-82-8 | Isopropylbenzene | 0.28 | J | 7.5 | | µg/L | RW-6A(11/8/2013) | 43/455 | 0.15 to 0.57 | 7.5 | 45 | n | NA | | N | | BSL | BSL |
| | 1634-04-4 | Methyl tert butyl ether | 0.24 | J | 171 | | µg/L | OB-25(7/6/2009) | 27/455 | 0.14 to 0.29 | 171 | 14 | c | NA | | Y | | ASL | ASL |
| | 108-87-2 | Methylcyclohexane | 0.23 | J | 2 | J | µg/L | SC-01(4/30/2008),SC-01(10/28/2009) | 35/455 | 0.11 to 0.35 | 2 | NA | | NA | | N | | NTX | NTX |
| | 75-09-2 | Methylene chloride | 0.85 | J | 1.2 | J | µg/L | OB-27(5/18/2011) | 3/455 | 0.16 to 0.86 | 1.2 | 11 | n | 5 | MCL | N | FOD | BSL | FOD,BSL |
| | 108-88-3 | Toluene | 0.16 | J | 198 | D | µg/L | RW-9(7/30/2008) | 69/455 | 0.15 to 45 | 198 | 110 | n | 1000 | MCL | Y | | ASL | ASL |
| | 79-01-6 | Trichloroethene | 0.7 | J | 13.7 | | µg/L | OB-03(9/9/2008) | 5/455 | 0.18 to 0.33 | 13.7 | 0.28 | n | 5 | MCL | Y | FOD | ASL | CLA |
| | 75-69-4 | Trichlorofluoromethane | 0.3 | J | 0.3 | J | µg/L | OB-02(5/16/2011) | 1/455 | 0.23 to 0.54 | 0.3 | 110 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 1330-20-7 | Xylenes | 0.22 | J | 81.8 | | µg/L | SC-01(4/27/2012) | 42/455 | 0.17 to 0.39 | 81.8 | 19 | n | NA | | Y | | ASL | ASL |

**Table 2.1**
**Occurrence, Distribution, and Selection of Constituents of Potential Concern**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | CAS Number | Chemical | Minimum Concentration (Qualifier) (1) | | Maximum Concentration (Qualifier) (1) | | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration Used for Screening (2) | Screening Toxicity Value (n/c) (3) | | Potential ARAR/TBC Value | Potential C Source (4) | COPC Flag (Y/N) | FOD | SL/TX | Rationale for Selection or Deletion (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tap Water | Semivolatile Organic Compounds (SVOCs) | | | | | | | | | | | | | | | | | | |
| | 91-57-6 | 2-Methylnaphthalene | 0.43 | J | 1.2 | J | µg/L | RW-6A(11/8/2013) | 10/439 | 0.29 to 3.8 | 1.2 | 3.6 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 83-32-9 | Acenaphthene | 0.107 | | 1.83 | | µg/L | OB-23(5/19/2011) | 19/439 | 0.014 to 0.2 | 1.83 | 53 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 208-96-8 | Acenaphthylene | 0.119 | | 0.17 | | µg/L | RW-10(4/19/2012) | 2/439 | 0.007 to 0.24 | 0.17 | NA | | NA | | N | FOD | NTX | FOD,NTX |
| | 98-86-2 | Acetophenone | 0.47 | J | 3.4 | | µg/L | RW-2(6/29/2010) | 20/434 | 0.29 to 19.9 | 3.4 | 190 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 120-12-7 | Anthracene | 0.124 | | 0.172 | | µg/L | OB-27(11/11/2013) | 5/439 | 0.01 to 0.2 | 0.172 | 180 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 56-55-3 | Benzo(a)anthracene | 0.142 | | 0.322 | | µg/L | SC-02(4/19/2012) | 4/439 | 0.012 to 0.12 | 0.322 | 0.034 | c | NA | | N | FOD | ASL | FOD |
| | 50-32-8 | Benzo(a)pyrene | 1.25 | | 1.25 | | µg/L | RW-6(4/27/2012) | 1/439 | 0.0049 to 0.12 | 1.25 | 0.0034 | c | 0.2 | MCL | N | FOD | ASL | FOD |
| | 205-99-2 | Benzo(b)fluoranthene | 0.22 | | 0.714 | | µg/L | RW-6(4/27/2012) | 3/439 | 0.01 to 0.1 | 0.714 | 0.034 | c | NA | | N | FOD | ASL | FOD |
| | 191-24-2 | Benzo(g,h,i)perylene | 0.118 | | 3.25 | | µg/L | RW-6(4/27/2012) | 3/439 | 0.01 to 0.16 | 3.25 | NA | | NA | | N | FOD | NTX | FOD,NTX |
| | 207-08-9 | Benzo(k)fluoranthene | 0.116 | | 1.24 | | µg/L | RW-6(4/27/2012) | 3/439 | 0.013 to 0.15 | 1.24 | 0.34 | c | NA | | N | FOD | ASL | FOD |
| | 117-81-7 | bis(2-Ethylhexyl)phthalate | 1.2 | J | 156 | | µg/L | RW-10A(6/2/2011) | 37/439 | 0.33 to 17.1 | 156 | 5.6 | c | 6 | MCL | Y | | ASL | ASL |
| | 86-74-8 | Carbazole | 0.47 | J | 0.59 | J | µg/L | OB-23(5/2/2008) | 3/439 | 0.17 to 3.6 | 0.59 | NA | | NA | | N | FOD | NTX | FOD,NTX |
| | 218-01-9 | Chrysene | 0.15 | | 0.169 | | µg/L | SC-02(4/19/2012) | 2/439 | 0.012 to 0.12 | 0.169 | 3.4 | c | NA | | N | FOD | BSL | FOD,BSL |
| | 53-70-3 | Dibenzo(a,h)anthracene | 0.106 | | 0.616 | | µg/L | RW-6(4/27/2012) | 3/439 | 0.017 to 0.17 | 0.616 | 0.0034 | c | NA | | N | FOD | ASL | FOD |
| | 132-64-9 | Dibenzofuran | 0.69 | J | 0.86 | J | µg/L | OB-23(5/19/2011) | 2/439 | 0.23 to 2.7 | 0.86 | 0.79 | n | NA | | N | FOD | ASL | FOD |
| | 84-66-2 | Diethyl phthalate | 1.1 | J | 3.4 | J | µg/L | OB-20B(11/8/2013) | 2/439 | 0.17 to 3.3 | 3.4 | 1500 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 131-11-3 | Dimethyl phthalate | 1.5 | J | 1.5 | J | µg/L | OB-20B(6/2/2010) | 1/439 | 0.23 to 2.8 | 1.5 | NA | | NA | | N | FOD | NTX | FOD,NTX |
| | 84-74-2 | di-n-butyl phthalate | 1 | | 4.7 | | µg/L | OB-04(9/15/2014) | 13/439 | 0.19 to 7.9 | 4.7 | 90 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 117-84-0 | di-n-octylphthalate | 1.1 | J | 1.1 | J | µg/L | RW-4A(5/25/2011) | 1/439 | 0.25 to 3.1 | 1.1 | 20 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 206-44-0 | Fluoranthene | 0.249 | | 0.249 | | µg/L | SC-02(4/19/2012) | 1/439 | 0.0096 to 0.13 | 0.249 | 80 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 86-73-7 | Fluorene | 0.129 | | 0.865 | | µg/L | OB-23(5/19/2011) | 16/439 | 0.015 to 0.17 | 0.865 | 29 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 0.135 | | 0.818 | | µg/L | RW-6(4/27/2012) | 3/439 | 0.011 to 0.14 | 0.818 | 0.034 | c | NA | | N | FOD | ASL | FOD |
| | 78-59-1 | Isophorone | 0.76 | J | 12.5 | | µg/L | RW-3D(5/24/2011) | 8/439 | 0.25 to 2.7 | 12.5 | 78 | c | NA | | N | FOD | BSL | FOD,BSL |
| | 91-20-3 | Naphthalene | 0.128 | | 9.1 | | µg/L | RW-6A(11/8/2013) | 57/438 | 0.014 to 6.9 | 9.1 | 0.17 | c | NA | | Y | | ASL | ASL |
| | 86-30-6 | N-Nitrosodiphenylamine | 0.4 | J | 1.6 | J | µg/L | OB-23(7/8/2009) | 19/439 | 0.21 to 3.1 | 1.6 | 12 | c | NA | | N | FOD | BSL | FOD,BSL |
| | 87-86-5 | Pentachlorophenol | 1.47 | J | 1.47 | J | µg/L | RW-10(4/19/2012) | 1/434 | 0.068 to 1 | 1.47 | 0.04 | c | 1 | MCL | N | FOD | ASL | FOD |
| | 85-01-8 | Phenanthrene | 0.121 | | 1.49 | | µg/L | RW-3DS(4/30/2012) | 46/439 | 0.016 to 0.502 | 1.49 | NA | | NA | | N | | NTX | NTX |
| | 108-95-2 | Phenol | 2.5 | J | 103 | | µg/L | RW-10(10/29/2009) | 17/438 | 0.55 to 13 | 103 | 580 | n | NA | | N | FOD | BSL | FOD,BSL |
| | 129-00-0 | Pyrene | 0.254 | | 0.254 | | µg/L | SC-02(4/19/2012) | 1/439 | 0.0081 to 0.15 | 0.254 | 12 | n | NA | | N | FOD | BSL | FOD,BSL |

**Table 2.1**
**Occurrence, Distribution, and Selection of Constituents of Potential Concern**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | CAS Number | Chemical | Minimum Concentration (Qualifier) (1) | | Maximum Concentration (Qualifier) (1) | | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration Used for Screening (2) | Screening Toxicity Value (n/c) (3) | | Potential ARAR/TBC Value | Potential C Source (4) | COPC Flag (Y/N) | FOD | SL/TX | Rationale for Selection or Deletion (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tap Water** | **Metals - Total** | | | | | | | | | | | | | | | | | | |
| | 7429-90-5 | Aluminum | 11.2 | J | 43100 | | µg/L | OB-25(9/18/2008) | 297/448 | 7.2 to 254 | 43100 | 2000 | n | NA | | Y | | ASL | ASL |
| | 7440-36-0 | Antimony | 1.3 | B | 17.8 | | µg/L | RW-4(6/30/2009) | 17/448 | 1.3 to 6 | 17.8 | 0.78 | n | 6 | MCL | N | FOD | ASL | FOD |
| | 7440-38-2 | Arsenic | 1.1 | B | 26.6 | | µg/L | OB-11R(9/11/2014) | 134/448 | 0.92 to 5.9 | 26.6 | 0.052 | c | 10 | MCL | Y | | ASL | ASL |
| | 7440-39-3 | Barium | 1.7 | J | 1570 | | µg/L | RW-11D(11/14/2013) | 431/448 | 3.7 to 200 | 1570 | 380 | n | 2000 | MCL | Y | | ASL | ASL |
| | 7440-41-7 | Beryllium | 0.2 | B | 4.7 | J | µg/L | RW-4(11/11/2013) | 16/448 | 0.1 to 1.1 | 4.7 | 2.5 | n | 4 | MCL | N | FOD | ASL | FOD |
| | 7440-43-9 | Cadmium | 0.2 | B | 11.8 | | µg/L | RW-5(10/27/2009) | 74/448 | 0.17 to 3 | 11.8 | 0.92 | n | 5 | MCL | Y | | ASL | ASL |
| | 7440-70-2 | Calcium | 3180 | B | 458000 | | µg/L | RW-11D(11/14/2013) | 450/450 | 0 to 0 | 458000 | NA | | NA | | N | | NTX | NUT |
| | 18540-29-9 | Chromium | 0.7 | B | 113 | | µg/L | RW-10(6/25/2010) | 181/447 | 0.53 to 20.8 | 113 | 0.035 | c | 100 | MCL | Y | | ASL | ASL |
| | 7440-48-4 | Cobalt | 0.4 | B | 50.4 | | µg/L | SC-02(5/5/2008) | 139/448 | 0.3 to 50 | 50.4 | 0.6 | n | NA | | Y | | ASL | ASL |
| | 7440-50-8 | Copper | 1 | B | 307 | | µg/L | RW-2(9/26/2014) | 198/448 | 0.7 to 10 | 307 | 80 | n | 1300 | MCL | Y | | ASL | ASL |
| | 7439-89-6 | Iron | 17.1 | B | 69500 | | µg/L | OB-25(9/18/2008) | 420/449 | 7.4 to 186 | 69500 | 1400 | n | NA | | Y | | ASL | ASL |
| | 7439-92-1 | Lead | 1 | B | 53.6 | | µg/L | OB-25(6/1/2010) | 129/448 | 0.94 to 4.2 | 53.6 | | L | 15 | AL | Y | | ASL | ASL |
| | 7439-95-4 | Magnesium | 23.2 | B | 50200 | | µg/L | OB-05(9/9/2008) | 435/450 | 16 to 5000 | 50200 | NA | | NA | | N | | NTX | NUT |
| | 7439-96-5 | Manganese | 0.3 | J | 16300 | | µg/L | OB-15B(6/11/2010) | 406/450 | 0.12 to 15 | 16300 | 43 | n | NA | | Y | | ASL | ASL |
| | 7439-97-6 | Mercury | 0.071 | B | 0.18 | B | µg/L | OB-20A(11/8/2013) | 14/449 | 0.049 to 0.33 | 0.18 | 0.063 | n | 2 | MCL | N | FOD | ASL | FOD |
| | 7440-02-0 | Nickel | 0.6 | B | 104 | | µg/L | OB-15B(6/11/2010) | 257/448 | 0.41 to 40.9 | 104 | 39 | n | NA | | Y | | ASL | ASL |
| | 7440-09-7 | Potassium | 288 | B | 291000 | | µg/L | RW-2(6/3/2011) | 445/449 | 48 to 10000 | 291000 | NA | | NA | | N | | NTX | NUT |
| | 7782-49-2 | Selenium | 1.6 | B | 10.1 | B | µg/L | RW-3DS(9/11/2014) | 84/448 | 1.5 to 10 | 10.1 | 10 | n | 50 | MCL | Y | | ASL | ASL |
| | 7440-21-3 | Silicon | 2070 | | 342000 | | µg/L | RW-2(9/26/2014) | 75/75 | 0 to 0 | 342000 | NA | | NA | | N | | NTX | NTX |
| | 7440-22-4 | Silver | 0.6 | B | 10.2 | B | µg/L | OB-11R(9/11/2014) | 94/449 | 0.53 to 10 | 10.2 | 9.4 | n | NA | | Y | | ASL | ASL |
| | 7440-23-5 | Sodium | 1510 | B | 406000 | | µg/L | RW-2(6/3/2011) | 445/449 | 3130 to 10000 | 406000 | NA | | NA | | N | | NTX | NUT |
| | 7440-28-0 | Thallium | 1 | J | 17.9 | B | µg/L | RW-4(11/11/2013) | 20/449 | 0.17 to 6.6 | 17.9 | 0.02 | n | 2 | MCL | N | FOD | ASL | FOD |
| | 7440-62-2 | Vanadium | 0.5 | B | 77.8 | | µg/L | OB-25(9/18/2008) | 209/448 | 0.43 to 50 | 77.8 | 8.6 | n | NA | | Y | | ASL | ASL |
| | 7440-66-6 | Zinc | 1.9 | B | 10900 | | µg/L | RW-10(10/30/2009) | 271/448 | 1.4 to 30 | 10900 | 600 | n | NA | | Y | | ASL | ASL |

**Table 2.1**
**Occurrence, Distribution, and Selection of Constituents of Potential Concern**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | CAS Number | Chemical | Minimum Concentration (Qualifier) (1) | | Maximum Concentration (Qualifier) (1) | | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration Used for Screening (2) | Screening Toxicity Value (n/c) (3) | | Potential ARAR/TBC Value | Potential C Source (4) | COPC Flag (Y/N) | FOD | SL/TX | Rationale for Selection or Deletion (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tap Water | Other | | | | | | | | | | | | | | | | | | |
| | 16887-00-6 | Chloride | 2000 | | 828000 | | µg/L | RW-2(7/14/2009) | 295/443 | 2000 to 2000 | 828000 | NA | | NA | | N | | NTX | NTX |
| | 57-12-5 | Cyanide | 14 | | 21 | | µg/L | OB-18(9/11/2008) | 3/84 | 10 to 10 | 21 | 0.15 | n | 200 | MCL | N | FOD | ASL | FOD |
| | 7782-41-4 | Fluoride | 230 | | 1400 | | µg/L | RW-2(5/16/2012) | 7/38 | 200 to 1500 | 1400 | 120 | n | 4000 | MCL | N | | ASL | NUT |
| | 74-82-8 | Methane | 1.8 | | 42700 | | µg/L | SC-01(4/27/2012) | 22/33 | 0.022 to 0.96 | 42700 | NA | | NA | | N | | NTX | NTX |
| | 14797-65-0 | Nitrogen, Nitrate + Nitrite | 100 | | 5500 | | µg/L | RW-2(9/16/2008) | 40/119 | 100 to 200 | 5500 | 200 | n | 1000 | MCL | N | | ASL | NUT |
| | PORG | Phosphorus, Total | 51 | | 330 | | µg/L | OB-20B(9/15/2008),OB-20B(4/27/2012) | 33/119 | 50 to 100 | 330 | NA | | NA | | N | | NTX | NTX |
| | 14859-67-7 | Radon (pCi/L) | 34 | LT | 1090 | | pCi/L | OB-20B(4/27/2012) | 22/32 | 31 to 44 | 1090 | NA | | 4000 | AMCL | N | | BSL | BSL |
| | SIL | Silica, Dissolved | 7300 | | 28800 | | µg/L | OB-27(4/25/2012) | 26/26 | 0 to 0 | 28800 | NA | | NA | | N | | NTX | NTX |
| | 14808-79-8 | Sulfate | 10000 | | 472000 | | µg/L | RW-3DS(9/11/2014) | 299/443 | 10000 to 12400 | 472000 | NA | | NA | | N | | NTX | NTX |

**General Notes:**

1. Concentrations in micrograms per liter (µg/L), except radon in picoCuries per liter (pCi/L).
2. All site data (2008-2014) except upgradient wells OB-01 and RW-1 used for COPC screening. Only constituents detected in one or more sample(s) are presented. Metals data are total (rather than dissolved) concentrations, assuming conservatively that groundwater used as drinking water is unfiltered.

**Footnotes:**

(1) Qualifier codes:
B (inorganic) = estimated result is between the detection limit and quantitation limit
D = diluted result
J = estimated result
LT = result is less than requested method detection limit and greater than sample-specific method detection limit

(2) Maximum detected concentration used for screening.

(3) USEPA Regional Screening Levels (RSLs) for tap water January 2015. RSLs based on noncarcinogenic effects were based on an THQ of 0.1. RSLs based on carcinogenic effects where the noncarcinogenic RSL is <10 times the carcinogenic RSL were represented by noncarcinogenic RSLs based on an THQ of 0.1. The following surrogates and assumptions regarding inorganic speciation were used for screening:
Chromium = Chromium VI
Fluoride = Fluorine (soluble fluoride)
Mercury = Elemental Mercury. Please note this screening value is based on the inhalation route, not the ingestion route. It was conservatively chosen as a screening value because it was lower than the value for ingestion only.
Nitrogen, Nitrate + Nitrite = Nitrite

Codes used for "Screening Toxicity Value":
c = screening value is based on carcinogenic effects
L = lead (screening value is the Action Level in drinking water)
n = screening value is based on noncarcinogenic effects

**Table 2.1**
**Occurrence, Distribution, and Selection of Constituents of Potential Concern**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | CAS Number | Chemical | Minimum Concentration (Qualifier) (1) | Maximum Concentration (Qualifier) (1) | Units | Location of Maximum Concentration | Detection Frequency | Range of Detection Limits | Concentration Used for Screening (2) | Screening Toxicity Value (n/c) (3) | Potential ARAR/TBC Value | Potential C Source (4) | COPC Flag (Y/N) | FOD | SL/TX | Rationale for Selection or Deletion (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

(4) The following surrogates were used to identify potential Applicable or Relevant and Appropriate Requirement (ARAR)/To be Considered (TBC) values:

Bromodichloromethane, chloroform = Total Trihalomethanes

Chromium = Total Chromium

Codes used for "Potential ARAR/TBC Source":

AL = Action Level

AMCL = Alternative Maximum Contaminant Level, http://www.nap.edu/catalog.php?record_id=6287

MCL = Maximum Contaminant Level, http://water.epa.gov/drink/contaminants/index.cfm

(5) Codes used for the "Rationale for Selection or Deletion":

ASL = above screening level

BSL = below screening level

CLA = chemical is classified as a class A carcinogen by USEPA

FOD = frequency of detection below 5 percent

NTX = no toxicity data and no screening value; compound will be discussed qualitatively

NUT = essential nutrient

**Acronyms and Abbreviations Not Defined Elsewhere:**

ARAR = Applicable or Relevant and Appropriate Requirement
BHHRA = Baseline Human Health Risk Assessment
CAS = Chemical Abstract Service
COPC = constituent of potential concern
N = no
NA = not available or not applicable
TBC = to be considered
THQ = target hazard quotient
USEPA = U.S. Environmental Protection Agency
Y = yes

**Table 3.1**
**Exposure Point Concentration Summary - Groundwater**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean (3) | 95% UCL (Distribution) (1) | Minimum Concentration (Qualifier) (4) | | Maximum Concentration (Qualifier) (4) | | Detection Frequency | Exposure Point Concentration Value (2) | Units | Statistic (2) | Rationale (2) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tap Water | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | 1,1-Dichloroethane | µg/L | 4.6E-01 | 8.3E-01 | 2.3E-01 | J | 8.9E+01 | J | 60/455 | 8.3E-01 | µg/L | 95th% UCL | UCL < Max |
| | Benzene | µg/L | 9.1E-01 | 1.5E+00 | 2.3E-01 | J | 8.8E+01 | | 86/455 | 1.5E+00 | µg/L | 95th% UCL | UCL < Max |
| | Methyl tert butyl ether | µg/L | 5.3E-01 | 1.3E+00 | 2.4E-01 | J | 1.7E+02 | | 27/455 | 1.3E+00 | µg/L | 95th% UCL | UCL < Max |
| | Toluene | µg/L | 2.7E+00 | 5.7E+00 | 1.6E-01 | J | 2.0E+02 | D | 69/455 | 5.7E+00 | µg/L | 95th% UCL | UCL < Max |
| | Trichloroethene | µg/L | 1.6E-01 | 2.6E-01 | 7.0E-01 | J | 1.4E+01 | | 5/455 | 2.6E-01 | µg/L | 95th% UCL | UCL < Max |
| | Xylenes | µg/L | 1.3E+00 | 2.9E+00 | 2.2E-01 | J | 8.2E+01 | | 42/455 | 2.9E+00 | µg/L | 95th% UCL | UCL < Max |
| | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | bis(2-Ethylhexyl)phthalate | µg/L | 1.1E+00 | 1.6E+00 | 1.2E+00 | J | 1.6E+02 | | 37/439 | 1.6E+00 | µg/L | 95th% UCL | UCL < Max |
| | Naphthalene | µg/L | 2.5E-01 | 3.1E-01 | 1.3E-01 | | 9.1E+00 | | 57/438 | 3.1E-01 | µg/L | 95th% UCL | UCL < Max |
| | **Metals - Total** | | | | | | | | | | | | |
| | Aluminum | µg/L | 7.0E+02 | 1.4E+03 | 1.1E+01 | J | 4.3E+04 | | 297/448 | 1.4E+03 | µg/L | 95th% UCL | UCL < Max |
| | Arsenic | µg/L | 2.4E+00 | 2.8E+00 | 1.1E+00 | B | 2.7E+01 | | 134/448 | 2.8E+00 | µg/L | 95th% UCL | UCL < Max |
| | Barium | µg/L | 6.8E+01 | 9.4E+01 | 1.7E+00 | J | 1.6E+03 | | 431/448 | 9.4E+01 | µg/L | 95th% UCL | UCL < Max |
| | Cadmium | µg/L | 4.7E-01 | 4.2E-01 | 2.0E-01 | B | 1.2E+01 | | 74/448 | 4.2E-01 | µg/L | 95th% UCL | UCL < Max |
| | Chromium | µg/L | 3.9E+00 | 4.3E+00 | 7.0E-01 | B | 1.1E+02 | | 181/447 | 4.3E+00 | µg/L | 95th% UCL | UCL < Max |
| | Cobalt | µg/L | 4.2E+00 | 2.6E+00 | 4.0E-01 | B | 5.0E+01 | | 139/448 | 2.6E+00 | µg/L | 95th% UCL | UCL < Max |
| | Copper | µg/L | 6.0E+00 | 7.1E+00 | 1.0E+00 | B | 3.1E+02 | | 198/448 | 7.1E+00 | µg/L | 95th% UCL | UCL < Max |
| | Iron | µg/L | 9.1E+03 | 1.2E+04 | 1.7E+01 | B | 7.0E+04 | | 420/449 | 1.2E+04 | µg/L | 95th% UCL | UCL < Max |
| | Lead | µg/L | 2.3E+00 | 2.8E+00 | 1.0E+00 | B | 5.4E+01 | | 129/448 | 2.3E+00 | µg/L | Arithmetic Mean | Lead |
| | Manganese | µg/L | 1.4E+03 | 1.9E+03 | 3.0E-01 | J | 1.6E+04 | | 406/450 | 1.9E+03 | µg/L | 95th% UCL | UCL < Max |
| | Nickel | µg/L | 5.4E+00 | 6.9E+00 | 6.0E-01 | B | 1.0E+02 | | 257/448 | 6.9E+00 | µg/L | 95th% UCL | UCL < Max |
| | Selenium | µg/L | 2.0E+00 | 2.3E+00 | 1.6E+00 | B | 1.0E+01 | B | 84/448 | 2.3E+00 | µg/L | 95th% UCL | UCL < Max |
| | Silver | µg/L | 9.7E-01 | 1.0E+00 | 6.0E-01 | B | 1.0E+01 | B | 94/449 | 1.0E+00 | µg/L | 95th% UCL | UCL < Max |
| | Vanadium | µg/L | 5.1E+00 | 3.4E+00 | 5.0E-01 | B | 7.8E+01 | | 209/448 | 3.4E+00 | µg/L | 95th% UCL | UCL < Max |
| | Zinc | µg/L | 3.7E+02 | 6.2E+02 | 1.9E+00 | B | 1.1E+04 | | 271/448 | 6.2E+02 | µg/L | 95th% UCL | UCL < Max |

**Table 3.1**
**Exposure Point Concentration Summary - Groundwater**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Medium: Groundwater |
| Exposure Medium: Groundwater |

**General Notes:**

Metals data are total (rather than dissolved) concentrations, assuming conservatively that groundwater used as drinking water is unfiltered.

**Footnotes;**

(1) ProUCL version 5.0 used to calculate 95th percentile upper confidence limits (UCLs) on the mean. The UCL presented is the UCL recommended by the software, except where the software recommended a 97.5% or 99% KM (Chebyshev) UCL; in this case, the UCL is the 95% KM (Chebyshev) or 95% Chebyshev (Mean, Sd) UCL.

(2) EPC is the lower of the 95th% UCL (where calculable) and the maximum detected concentration. The arithmetic average concentration will be used to estimate risks associated with lead in water.

(3) Arithmetic mean concentrations calculated using one-half the detection limit for non-detects.

(4) Qualifier codes:

B (inorganic) = estimated result is between the detection limit and quantitation limit

D = diluted result

J = estimated result

**Acronyms and Abbreviations Not Defined Elsewhere:**

BHHRA = Baseline Human Health Risk Assessment

EPC = exposure point concentration

µg/L = micrograms per liter

**Table 3.2**
**Exposure Point Concentrations Summary - Shower Air**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Medium: Groundwater |
| Exposure Medium: Air |

| Exposure Point | Chemical of Potential Concern | Units | Cgw (1) | Exposure Point Concentration | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Adult - CT (2) | Adult - RME (2) | Youth - CT (2) | Youth - RME (2) | Child - CT (2) | Child - RME (2) | Units |
| Shower Air | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | 1,1-Dichloroethane | µg/L | 8.3E-01 | 2.9E+00 | 8.6E+00 | 2.6E+00 | 7.1E+00 | 2.7E+00 | 6.6E+00 | µg/m$^3$ |
| | Benzene | µg/L | 1.5E+00 | 5.1E+00 | 1.5E+01 | 4.6E+00 | 1.3E+01 | 4.7E+00 | 1.2E+01 | µg/m$^3$ |
| | Methyl tert butyl ether | µg/L | 1.3E+00 | 3.8E+00 | 1.1E+01 | 3.5E+00 | 9.4E+00 | 3.6E+00 | 8.8E+00 | µg/m$^3$ |
| | Toluene | µg/L | 5.7E+00 | 1.8E+01 | 5.4E+01 | 1.6E+01 | 4.4E+01 | 1.7E+01 | 4.2E+01 | µg/m$^3$ |
| | Trichloroethene | µg/L | 2.6E-01 | 8.8E-01 | 2.7E+00 | 8.1E-01 | 2.2E+00 | 8.3E-01 | 2.0E+00 | µg/m$^3$ |
| | Xylenes | µg/L | 2.9E+00 | 9.5E+00 | 2.9E+01 | 8.6E+00 | 2.3E+01 | 8.9E+00 | 2.2E+01 | µg/m$^3$ |
| | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | Naphthalene | µg/L | 3.1E-01 | 8.7E-01 | 2.6E+00 | 7.9E-01 | 2.2E+00 | 8.2E-01 | 2.0E+00 | µg/m$^3$ |

**General Notes:**
Volatile COPCs only.

**Footnotes:**
(1) Concentration in groundwater; see Table 3.1.
(2) EPC in shower air estimated using the Andelman model as modified by Schaum et al. (1994) (see Appendix C).

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
Cgw = concentration in groundwater
COPC = constituent of potential concern
CT = central tendency exposure
EPC = exposure point concentration
RME = reasonable maximum exposure
µg/L = micrograms per liter
µg/m$^3$ = micrograms per cubic meter

**Table 3.2**
**Exposure Point Concentrations Summary - Shower Air**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Medium: Groundwater |
| Exposure Medium: Air |

**References:**

Schaum, J., K. Hoang, R. Kinerson, J. Moya and R.G.M. Wang. 1994. *Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water.* In: Water Contamination and Health. R.G.M. Wang, ed. Marcel Dekker, Inc., New York, pp.305-321.

**Table 4.1.CT**
**Values for Daily Intake Calculations**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor: Hypothetical Future Resident
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/Reference | Intake Equation/Model Name |
|---|---|---|---|---|---|---|---|---|---|
| Ingestion | Hypothetical Future Resident | Adult | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | µg/L | See Table 3.1 | Chronic Daily Intake (CDI) (mg/kg-day) = CW x CF x IRW x EF x ED x 1/BW x 1/AT |
| | | | | CF | Conversion Factor | 0.001 | mg/µg | -- | |
| | | | | IRW | Ingestion Rate of Drinking Water | 1.0 | L/day | USEPA 2011 (a) | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 0 | years | USEPA 1997 (b) | |
| | | | | BW | Body Weight | 70 | kg | USEPA 1989 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 0 | days | Based on ED of 0 years | |
| | | Youth (7 to 16 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | µg/L | See Table 3.1 | |
| | | | | CF | Conversion Factor | 0.001 | mg/µg | -- | |
| | | | | IRW | Ingestion Rate of Drinking Water | 0.48 | L/day | USEPA 2011 (d) | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 3 | years | USEPA 1997 (b) | |
| | | | | BW | Body Weight | 45 | kg | USEPA 1997 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 1,095 | days | Based on ED of 3 years | |
| | | Young Child (1 to 6 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | µg/L | See Table 3.1 | |
| | | | | CF | Conversion Factor | 0.001 | mg/µg | -- | |
| | | | | IRW | Ingestion Rate of Drinking Water | 0.33 | L/day | USEPA 2011 (e) | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 6 | years | USEPA 1997 (b) | |
| | | | | BW | Body Weight | 15 | kg | USEPA 1991 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 2,190 | days | Based on ED of 6 years | |

**Table 4.1.CT**
**Values for Daily Intake Calculations**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor: Hypothetical Future Resident
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/Reference | Intake Equation/Model Name |
|---|---|---|---|---|---|---|---|---|---|
| Dermal | Hypothetical Future Resident | Adult | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | μg/L | See Table 3.1 | Dermal Absorbed Dose (DAD) (mg/kg-day) = DAevent x EvF x EF x ED x SA x 1/BW x 1/AT<br><br>Absorbed Dose per Event (DAevent) (mg/cm$^2$-event) =<br>For organics (t-event ≤ t*):<br>2 FA x Kp x CW x CF1 x CF2 x SQRT(6 x tau-event x t-event x 1/pi)<br>For organics (t-event > t*):<br>FA x Kp x CW x CF1 x CF2 x {(t-event/(1 + B)) +<br>2 x tau-event x ((1 + (3B) + (3 B$^2$)) / (1 + B)$^2$)}<br>For inorganics:<br>Kp x CW x CF1 x CF2 x t-event<br><br>and where t-event = ET |
| | | | | CF1 | Conversion Factor | 0.001 | mg/μg | -- | |
| | | | | CF2 | Conversion Factor | 0.001 | L/cm$^3$ | -- | |
| | | | | FA | Fraction Absorbed Water | chemical-specific | unitless | USEPA 2004 | |
| | | | | Kp | Permeability Coefficient | chemical-specific | cm/hour | USEPA 2004 | |
| | | | | B | Permeability Ratio | chemical-specific | unitless | USEPA 2004 | |
| | | | | t* | Time to Reach Steady State | chemical-specific | hours | USEPA 2004 | |
| | | | | tau-event | Lag Time per Event | chemical-specific | hours/event | USEPA 2004 | |
| | | | | SA | Skin Surface Area Available for Contact | 19,619 | cm$^2$ | USEPA 2011 (f) | |
| | | | | ET | Exposure Time/Event Duration | 0.33 | hours/event | USEPA 2011 (g) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 0 | years | USEPA 1997 (b) | |
| | | | | BW | Body Weight | 70 | kg | USEPA 1989 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 0 | days | Based on ED of 0 years | |
| | | Youth (7 to 16 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | μg/L | See Table 3.1 | |
| | | | | CF1 | Conversion Factor | 0.001 | mg/μg | -- | |
| | | | | CF2 | Conversion Factor | 0.001 | L/cm$^3$ | -- | |
| | | | | FA | Fraction Absorbed Water | chemical-specific | unitless | USEPA 2004 | |
| | | | | Kp | Permeability Coefficient | chemical-specific | cm/hour | USEPA 2004 | |
| | | | | B | Permeability Ratio | chemical-specific | unitless | USEPA 2004 | |
| | | | | t* | Time to Reach Steady State | chemical-specific | hours | USEPA 2004 | |
| | | | | tau-event | Lag Time per Event | chemical-specific | hours/event | USEPA 2004 | |
| | | | | SA | Skin Surface Area Available for Contact | 14,110 | cm$^2$ | USEPA 2011 (h) | |
| | | | | ET | Exposure Time/Event Duration | 0.30 | hours/event | USEPA 2011 (i) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 3 | years | USEPA 1997 (b) | |
| | | | | BW | Body Weight | 45 | kg | USEPA 1997 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 1,095 | days | Based on ED of 3 years | |
| | | Young Child (1 to 6 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | μg/L | See Table 3.1 | |
| | | | | CF1 | Conversion Factor | 0.001 | mg/μg | -- | |
| | | | | CF2 | Conversion Factor | 0.001 | L/cm$^3$ | -- | |
| | | | | FA | Fraction Absorbed Water | chemical-specific | unitless | USEPA 2004 | |
| | | | | Kp | Permeability Coefficient | chemical-specific | cm/hour | USEPA 2004 | |
| | | | | B | Permeability Ratio | chemical-specific | unitless | USEPA 2004 | |
| | | | | t* | Time to Reach Steady State | chemical-specific | hours | USEPA 2004 | |
| | | | | tau-event | Lag Time per Event | chemical-specific | hours/event | USEPA 2004 | |
| | | | | SA | Skin Surface Area Available for Contact | 7,500 | cm$^2$ | USEPA 2011 (j) | |
| | | | | ET | Exposure Time/Event Duration | 0.31 | hours/event | USEPA 2011 (k) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 6 | years | USEPA 1997 (b) | |
| | | | | BW | Body Weight | 15 | kg | USEPA 1991 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 2,190 | days | Based on ED of 6 years | |

**Table 4.1.CT**
**Values for Daily Intake Calculations**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Receptor: Hypothetical Future Resident |
| Medium: Groundwater |
| Exposure Medium: Groundwater |

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/Reference | Intake Equation/Model Name |
|---|---|---|---|---|---|---|---|---|---|
| Inhalation | Hypothetical Future Resident | Adult | Tap Water | CA | Chemical Concentration in Air | chemical-specific | μg/m³ | See shower model (l) | Inhaled Dose (μg/m³) = CA x ET x EvF x EF x ED x 1/AT |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 0 | years | USEPA 1997 (b) | |
| | | | | ET | Exposure Time/Event Duration | 0.47 | hours/event | USEPA 2011 (g) | |
| | | | | ATc | Averaging Time - Cancer | 613,200 | hours | USEPA 2009. Equivalent to 25,550 days. (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 0 | hours | Based on ED of 0 years | |
| | | Youth (7 to 16 years) | Tap Water | CA | Chemical Concentration in Air | chemical-specific | μg/m³ | See shower model (l) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 3 | years | USEPA 1997 (b) | |
| | | | | ET | Exposure Time/Event Duration | 0.42 | hours/event | USEPA 2011 (i) | |
| | | | | ATc | Averaging Time - Cancer | 613,200 | hours | USEPA 2009. Equivalent to 25,550 days. (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 26,280 | hours | Based on ED of 3 years | |
| | | Young Child (1 to 6 years) | Tap Water | CA | Chemical Concentration in Air | chemical-specific | μg/m³ | See shower model (l) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 6 | years | USEPA 1997 (b) | |
| | | | | ET | Exposure Time/Event Duration | 0.43 | hours/event | USEPA 2011 (k) | |
| | | | | ATc | Averaging Time - Cancer | 613,200 | hours | USEPA 2009. Equivalent to 25,550 days. (c) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 52,560 | hours | Based on ED of 6 years | |

**Footnotes:**
(a) Age-weighted mean value of per capita drinking water ingestion rate for individuals ages 17 to 52 years (Table 3-1, USEPA 2011).
(b) The total exposure duration is 9 years (USEPA 1997). Assumes 6 years of exposure as a young child, 3 years of exposure as a youth, and 0 years of exposure as an adult.
(c) The averaging time for cancer risk is the expected lifespan of 70 years expressed in days.
(d) Age-weighted mean value of per capita drinking water ingestion rate for individuals ages 7 to 16 years (Table 3-1, USEPA 2011).
(e) Age-weighted mean value of per capita drinking water ingestion rate for individuals ages 1 to 6 years (Table 3-1, USEPA 2011).
(f) Age-weighted mean total body skin surface area value, male and female combined, ages 17 to 52 years (Table 7-1, USEPA 2011).
(g) Represents the mean showering time for ages 16 to <21 years; total exposure time for inhalation includes mean time spent in the shower room after showering (Table 16-28, USEPA 2011).
(h) Age-weighted mean total body skin surface area value, male and female combined, ages 7 to 16 years (Table 7-1, USEPA 2011).
(i) Age-weighted average of the mean showering time for ages 7 to 16 years; total exposure time for inhalation includes age-weighted average of mean time spent in the shower room after showering (Table 16-28, USEPA 2011).
(j) Age-weighted mean total body skin surface area value, male and female combined, ages 1 to 6 years (Table 7-1, USEPA 2011).
(k) Age-weighted average of the mean showering time for ages 1 to 6 years; total exposure time for inhalation includes age-weighted average of mean time spent in the shower room after showering (Table 16-28, USEPA 2011).
(l) Concentrations of volatile constituents in shower air will be estimated using the Andelman model as modified by Schaum et al. (1994).

**Acronyms and Abbreviations:**

| | | |
|---|---|---|
| -- = not applicable | kg = kilograms | mg/kg-day = milligram per kilogram per day |
| BHHRA = Baseline Human Health Risk Assessment | L/cm³ = liters per cubic centimeter | μg/L = micrograms per liter |
| cm/hour = centimeters per hour | L/day = liters per day | μg/m³ = micrograms per cubic meter |
| cm² = square centimeters | mg/μg = milligrams per microgram | USEPA = U.S. Environmental Protection Agency |

**References:**

Schaum, J., K. Hoang, R. Kinerson, J. Moya, and R.G.M. Wang. 1994. *Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water*. In: Water Contamination and Health. R.G.M. Wang, ed. Marcel Dekker, Inc., New York, pp.305-321.
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**Table 4.1.RME**
**Values for Daily Intake Calculations**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor: Hypothetical Future Resident
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/Reference | Intake Equation/Model Name |
|---|---|---|---|---|---|---|---|---|---|
| Ingestion | Hypothetical Future Resident | Adult | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | µg/L | See Table 3.1 | Chronic Daily Intake (CDI) (mg/kg-day) = CW x CF x IRW x EF x ED x 1/BW x 1/AT |
| | | | | CF | Conversion Factor | 0.001 | mg/µg | -- | |
| | | | | IRW | Ingestion Rate of Drinking Water | 2 | L/day | USEPA 1989 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 36 | years | USEPA Decision (a) | |
| | | | | BW | Body Weight | 70 | kg | USEPA 1989 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 13,140 | days | Based on ED of 36 years | |
| | | Youth (7 to 16 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | µg/L | See Table 3.1 | |
| | | | | CF | Conversion Factor | 0.001 | mg/µg | -- | |
| | | | | IRW | Ingestion Rate of Drinking Water | 2 | L/day | USEPA 1989 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 10 | years | USEPA Decision (a) | |
| | | | | BW | Body Weight | 45 | kg | USEPA 1997 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 3,650 | days | Based on ED of 10 years | |
| | | Young Child (1 to 6 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | µg/L | See Table 3.1 | |
| | | | | CF | Conversion Factor | 0.001 | mg/µg | -- | |
| | | | | IRW | Ingestion Rate of Drinking Water | 1 | L/day | USEPA 1989 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 6 | years | USEPA Decision (a) | |
| | | | | BW | Body Weight | 15 | kg | USEPA 1991 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 2,190 | days | Based on ED of 6 years | |

**Table 4.1.RME**
**Values for Daily Intake Calculations**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor: Hypothetical Future Resident
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/Reference | Intake Equation/Model Name |
|---|---|---|---|---|---|---|---|---|---|
| Dermal | Hypothetical Future Resident | Adult | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | μg/L | See Table 3.1 | Dermal Absorbed Dose (DAD) (mg/kg-day) = DAevent x EvF x EF x ED x SA x 1/BW x 1/AT<br><br>Absorbed Dose per Event (DAevent) (mg/cm$^2$-event) =<br>For organics (t-event ≤ t*):<br>2 FA x Kp x CW x CF1 x CF2 x SQRT(6 x tau-event x t-event x 1/pi)<br>For organics (t-event > t*):<br>FA x Kp x CW x CF1 x CF2 x {(t-event/(1 + B)) + 2 x tau-event x ((1 + (3B) + (3 B$^2$)) / (1 + B)$^2$)}<br>For inorganics:<br>Kp x CW x CF1 x CF2 x t-event<br><br>and where t-event = ET |
| | | | | CF1 | Conversion Factor | 0.001 | mg/μg | -- | |
| | | | | CF2 | Conversion Factor | 0.001 | L/cm$^3$ | -- | |
| | | | | FA | Fraction Absorbed Water | chemical-specific | unitless | USEPA 2004 | |
| | | | | Kp | Permeability Coefficient | chemical-specific | cm/hour | USEPA 2004 | |
| | | | | B | Permeability Ratio | chemical-specific | unitless | USEPA 2004 | |
| | | | | t* | Time to Reach Steady State | chemical-specific | hours | USEPA 2004 | |
| | | | | tau-event | Lag Time per Event | chemical-specific | hours/event | USEPA 2004 | |
| | | | | SA | Skin Surface Area Available for Contact | 19,619 | cm$^2$ | USEPA 2011 (c) | |
| | | | | ET | Exposure Time/Event Duration | 0.67 | hours/event | USEPA 2011 (d) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 36 | years | USEPA Decision (a) | |
| | | | | BW | Body Weight | 70 | kg | USEPA 1989 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 13,140 | days | Based on ED of 36 years | |
| | | Youth (7 to 16 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | μg/L | See Table 3.1 | |
| | | | | CF1 | Conversion Factor | 0.001 | mg/μg | -- | |
| | | | | CF2 | Conversion Factor | 0.001 | L/cm$^3$ | -- | |
| | | | | FA | Fraction Absorbed Water | chemical-specific | unitless | USEPA 2004 | |
| | | | | Kp | Permeability Coefficient | chemical-specific | cm/hour | USEPA 2004 | |
| | | | | B | Permeability Ratio | chemical-specific | unitless | USEPA 2004 | |
| | | | | t* | Time to Reach Steady State | chemical-specific | hours | USEPA 2004 | |
| | | | | tau-event | Lag Time per Event | chemical-specific | hours/event | USEPA 2004 | |
| | | | | SA | Skin Surface Area Available for Contact | 14,110 | cm$^2$ | USEPA 2011 (e) | |
| | | | | ET | Exposure Time/Event Duration | 0.52 | hours/event | USEPA 2011 (f) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 10 | years | USEPA Decision (a) | |
| | | | | BW | Body Weight | 45 | kg | USEPA 1997 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 3,650 | days | Based on ED of 10 years | |
| | | Young Child (1 to 6 years) | Tap Water | CW | Chemical Concentration in Groundwater | chemical-specific | μg/L | See Table 3.1 | |
| | | | | CF1 | Conversion Factor | 0.001 | mg/μg | -- | |
| | | | | CF2 | Conversion Factor | 0.001 | L/cm$^3$ | -- | |
| | | | | FA | Fraction Absorbed Water | chemical-specific | unitless | USEPA 2004 | |
| | | | | Kp | Permeability Coefficient | chemical-specific | cm/hour | USEPA 2004 | |
| | | | | B | Permeability Ratio | chemical-specific | unitless | USEPA 2004 | |
| | | | | t* | Time to Reach Steady State | chemical-specific | hours | USEPA 2004 | |
| | | | | tau-event | Lag Time per Event | chemical-specific | hours/event | USEPA 2004 | |
| | | | | SA | Skin Surface Area Available for Contact | 7,500 | cm$^2$ | USEPA 2011 (g) | |
| | | | | ET | Exposure Time/Event Duration | 0.50 | hours/event | USEPA 2011 (h) | |
| | | | | EvF | Event Frequency | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 6 | years | USEPA Decision (a) | |
| | | | | BW | Body Weight | 15 | kg | USEPA 1991 | |
| | | | | ATc | Averaging Time - Cancer | 25,550 | days | USEPA 1989 (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 2,190 | days | Based on ED of 6 years | |

**Table 4.1.RME**
**Values for Daily Intake Calculations**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor: Hypothetical Future Resident
Medium: Groundwater
Exposure Medium: Groundwater

| Exposure Route | Receptor Population | Receptor Age | Exposure Point | Parameter Code | Parameter Definition | Value | Units | Rationale/Reference | Intake Equation/Model Name |
|---|---|---|---|---|---|---|---|---|---|
| Inhalation | Hypothetical Future Resident | Adult | Tap Water | CA | Chemical Concentration in Air | chemical-specific | μg/m³ | See shower model (i) | Inhaled Dose (μg/m³) = CA x ET x EvF x EF x ED x 1/AT |
| | | | | EvF | Exposure Time/Event Duration | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 36 | years | USEPA Decision (a) | |
| | | | | ET | Exposure Time/Event Duration | 0.92 | hours/event | USEPA 2011 (d) | |
| | | | | ATc | Averaging Time - Cancer | 613,200 | hours | USEPA 2009. Equivalent to 25,550 days. (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 315,360 | hours | Based on ED of 36 years | |
| | | Youth (7 to 16 years) | Tap Water | CA | Chemical Concentration in Air | chemical-specific | μg/m³ | See shower model (i) | |
| | | | | EvF | Exposure Time/Event Duration | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 10 | years | USEPA Decision (a) | |
| | | | | ET | Exposure Time/Event Duration | 0.79 | hours/event | USEPA 2011 (f) | |
| | | | | ATc | Averaging Time - Cancer | 613,200 | hours | USEPA 2009. Equivalent to 25,550 days. (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 87,600 | hours | Based on ED of 10 years | |
| | | Young Child (1 to 6 years) | Tap Water | CA | Chemical Concentration in Air | chemical-specific | μg/m³ | See shower model (i) | |
| | | | | EvF | Exposure Time/Event Duration | 1 | events/day | USEPA 2004 | |
| | | | | EF | Exposure Frequency | 350 | days/year | USEPA 1991 | |
| | | | | ED | Exposure Duration | 6 | years | USEPA Decision (a) | |
| | | | | ET | Exposure Time/Event Duration | 0.72 | hours/event | USEPA 2011 (h) | |
| | | | | ATc | Averaging Time - Cancer | 613,200 | hours | USEPA 2009. Equivalent to 25,550 days. (b) | |
| | | | | ATnc | Averaging Time - Non-Cancer | 52,560 | hours | Based on ED of 6 years | |

Notes:
(a) The total exposure duration is 52 years (USEPA decision presented during a conference call on September 30, 2010). Assumes 6 years of exposure as a young child, 10 years of exposure as a youth, and 36 years of exposure as an adult.
(b) The averaging time for cancer risk is the expected lifespan of 70 years expressed in days.
(c) Age-weighted mean total body skin surface area value, male and female combined, ages 17 to 52 years (Table 7-1, USEPA 2011).
(d) Represents the 90th percentile showering time for ages 16 to <21 years; total exposure time for inhalation includes 90th percentile of time spent in the shower room after showering (Table 16-28, USEPA 2011).
(e) Age-weighted mean total body skin surface area value, male and female combined, ages 7 to 16 years (Table 7-1, USEPA 2011).
(f) Age-weighted average of the 90th percentile showering time for ages 7 to 16 years; total exposure time for inhalation includes age-weighted average of 90th percentile time spent in the shower room after showering (Table 16-28, USEPA 2011).
(g) Age-weighted mean total body skin surface area value, male and female combined, ages 1 to 6 years (Table 7-1, USEPA 2011).
(h) Age-weighted average of the 90th percentile showering time for ages 1 to 6 years; total exposure time for inhalation includes age-weighted average of 90th percentile time spent in the shower room after showering (Table 16-28, USEPA 2011).
(i) Concentrations of volatile constituents in shower air will be estimated using the Andelman model as modified by Schaum et al. (1994).

**Acronyms and Abbreviations:**

-- = not applicable
BHHRA = Baseline Human Health Risk Assessment
cm/hour = centimeters per hour
$cm^2$ = square centimeters
kg = kilograms
$L/cm^3$ = liters per cubic centimeter
L/day = liters per day
mg/μg = milligrams per microgram
mg/kg-day = milligram per kilogram per day
μg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter
USEPA = U.S. Environmental Protection Agency

**References:**


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**Table 4.2**
**Parameters Used to Calculate Estimated Dermal Absorption**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| Chemical of Potential Concern | COPC in Groundwater ? (Y/N) | Kp cm/hour (3),(4) | B unitless (1) | FA unitless (1) | tau-event hours/event (1),(4) | t* hours (1) | DA-event t-event = 0.30 hours/event cm/event (1),(2) | DA-event t-event = 0.31 hours/event cm/event (1),(2) | DA-event t-event = 0.33 hours/event cm/event (1),(2) | DA-event t-event = 0.50 hours/event cm/event (1),(2) | DA-event t-event = 0.52 hours/event cm/event (1),(2) | DA-event t-event = 0.67 hours/event cm/event (1),(2) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| 1,1-Dichloroethane | Y | 6.8E-03 | 2.6E-02 | 1.0E+00 | 3.8E-01 | 9.0E-01 | 6.3E-03 | 6.4E-03 | 6.6E-03 | 8.1E-03 | 8.3E-03 | 9.4E-03 |
| Benzene | Y | 1.5E-02 | 5.1E-02 | 1.0E+00 | 2.9E-01 | 6.9E-01 | 1.2E-02 | 1.2E-02 | 1.3E-02 | 1.6E-02 | 1.6E-02 | 1.8E-02 |
| Methyl tert butyl ether | Y | 2.1E-03 | 7.6E-03 | 1.0E+00 | 3.3E-01 | 7.9E-01 | 1.8E-03 | 1.9E-03 | 1.9E-03 | 2.4E-03 | 2.4E-03 | 2.7E-03 |
| Toluene | Y | 3.1E-02 | 1.1E-01 | 1.0E+00 | 3.4E-01 | 8.3E-01 | 2.8E-02 | 2.8E-02 | 2.9E-02 | 3.6E-02 | 3.6E-02 | 4.1E-02 |
| Trichloroethene | Y | 1.2E-02 | 5.1E-02 | 1.0E+00 | 5.7E-01 | 1.4E+00 | 1.3E-02 | 1.3E-02 | 1.4E-02 | 1.7E-02 | 1.7E-02 | 2.0E-02 |
| Xylenes | Y | 5.0E-02 | 2.0E-01 | 1.0E+00 | 4.1E-01 | 9.9E-01 | 4.9E-02 | 4.9E-02 | 5.1E-02 | 6.3E-02 | 6.4E-02 | 7.3E-02 |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | Y | 2.5E-02 | 1.9E-01 | 8.0E-01 | 1.6E+01 | 3.9E+01 | 1.2E-01 | 1.2E-01 | 1.3E-01 | 1.6E-01 | 1.6E-01 | 1.8E-01 |
| Naphthalene | Y | 6.3E-03 | 2.7E-02 | 1.0E+00 | 1.2E+00 | 2.8E+00 | 1.0E-02 | 1.1E-02 | 1.1E-02 | 1.3E-02 | 1.4E-02 | 1.5E-02 |
| **Metals - Total** | | | | | | | | | | | | |
| Aluminum | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Arsenic | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Barium | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Cadmium | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Chromium | Y | 2.0E-03 | — | — | — | — | 6.0E-04 | 6.2E-04 | 6.6E-04 | 1.0E-03 | 1.0E-03 | 1.3E-03 |
| Cobalt | Y | 4.0E-04 | — | — | — | — | 1.2E-04 | 1.2E-04 | 1.3E-04 | 2.0E-04 | 2.1E-04 | 2.7E-04 |
| Copper | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Iron | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Lead | Y | 1.0E-04 | — | — | — | — | 3.0E-05 | 3.1E-05 | 3.3E-05 | 5.0E-05 | 5.2E-05 | 6.7E-05 |
| Manganese | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Nickel | Y | 2.0E-04 | — | — | — | — | 6.0E-05 | 6.2E-05 | 6.6E-05 | 1.0E-04 | 1.0E-04 | 1.3E-04 |
| Selenium | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Silver | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Vanadium | Y | 1.0E-03 | — | — | — | — | 3.0E-04 | 3.1E-04 | 3.3E-04 | 5.0E-04 | 5.2E-04 | 6.7E-04 |
| Zinc | Y | 6.0E-04 | — | — | — | — | 1.8E-04 | 1.9E-04 | 2.0E-04 | 3.0E-04 | 3.1E-04 | 4.0E-04 |

**Footnotes:**

(1) Obtained from or calculated from equations in Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), July 2004, Lead in water evaluated separately via USEPA lead models.

(2) Calculation of DA-event does not include the term for constituent concentration in water expressed in milligrams per cubic centimeter (mg/cm$^3$).

(3) Obtained from chemical-specific parameters for USEPA Regional Screening Levels (RSLs) (November 2012).

(4) Kp and tau-event values for naphthalene obtained from Sartorelli et al. (1999) (Sartorelli, P., A. Cenni, G. Matteucci, L. Montomoli, M.T. Novelli and S. Palmi. 1999. *Dermal exposure assessment of polycyclic aromatic hydrocarbons: in vitro percutaneous penetration from lubricating oil* . Int. Arch. Occup. Environ. Health 72: 528-532.)

**Acronyms and Abbreviations:**

— = not applicable
B = ratio of permeability coefficients through stratum corneum and viable epidermis
BHHRA = Baseline Human Health Risk Assessment
cm = centimeters
cm/hour = centimeters per hour
COPC = constituent of potential concern
DA-event = absorbed dose per event
FA = fraction of absorbed water
Kp = dermal permeability coefficient
N = no
t* = time to reach steady state
t-event = time per event
tau-event = lag time per event
USEPA = U.S. Environmental Protection Agency
Y = yes

**Table 5.1**
**Non-Cancer Toxicity Data -- Oral and Dermal Pathways**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| CAS Number | Chemical of Potential Concern (2),(5) | Chronic/ Subchronic | Oral RfD | | Oral Absorption Efficiency for Dermal (1) | Absorbed RfD for Dermal | | Primary Target Organ(s) (3) | Combined Uncertainty/Modifying Factors | RfD:Target Organ(s) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Value | Units | | Value (1) | Units | | | Source(s) (4) | Date(s) (MM/DD/YYYY) |
| **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | |
| 75-34-3 | 1,1-Dichloroethane | chronic | 2.0E-01 | mg/kg/day | 1 | 2.0E-01 | mg/kg/day | kidney | 3000 | PPRTV | 11/11/2014 |
| 71-43-2 | Benzene | chronic | 4.0E-03 | mg/kg/day | 1 | 4.0E-03 | mg/kg/day | immune system | 300 | IRIS | 11/11/2014 |
| 1634-04-4 | Methyl tert butyl ether | NA | NA | mg/kg/day | 1 | NA | mg/kg/day | NA | NA | NA | 11/11/2014 |
| 108-88-3 | Toluene | chronic | 8.0E-02 | mg/kg/day | 1 | 8.0E-02 | mg/kg/day | kidney | 3000 | IRIS | 11/11/2014 |
| 79-01-6 | Trichloroethene | chronic | 5.0E-04 | mg/kg/day | 1 | 5.0E-04 | mg/kg/day | heart, development, immune system | 10-1000 | IRIS | 11/11/2014 |
| 1330-20-7 | Xylenes | NA | NA | mg/kg/day | 1 | NA | mg/kg/day | body weight, mortality | 1000 | NA | 11/11/2014 |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | |
| 117-81-7 | bis(2-Ethylhexyl)phthalate | chronic | 2.0E-02 | mg/kg/day | 1 | 2.0E-02 | mg/kg/day | liver | 1000 | IRIS | 11/11/2014 |
| 91-20-3 | Naphthalene | chronic | 2.0E-02 | mg/kg/day | 1 | 2.0E-02 | mg/kg/day | body weight | 3000 | IRIS | 11/11/2014 |
| **Metals - Total** | | | | | | | | | | | |
| 7429-90-5 | Aluminum | chronic | 1.0E+00 | mg/kg/day | 1 | 1.0E+00 | mg/kg/day | developmental, neurobehavioral | 100 | PPRTV | 11/11/2014 |
| 7440-38-2 | Arsenic | chronic | 3.0E-04 | mg/kg/day | 1 | 3.0E-04 | mg/kg/day | skin, vascular | 3 | IRIS | 11/11/2014 |
| 7440-39-3 | Barium | chronic | 2.0E-01 | mg/kg/day | 0.07 | 1.4E-02 | mg/kg/day | kidney | 300 | IRIS | 11/11/2014 |
| 7440-43-9 | Cadmium | chronic | 5.0E-04 | mg/kg/day | 0.05 | 2.5E-05 | mg/kg/day | kidney | 10 | IRIS | 11/11/2014 |
| 18540-29-9 | Chromium | chronic | 3.0E-03 | mg/kg/day | 0.025 | 7.5E-05 | mg/kg/day | NR | 900 | IRIS | 11/11/2014 |
| 7440-48-4 | Cobalt | chronic | 3.0E-04 | mg/kg/day | 1 | 3.0E-04 | mg/kg/day | thyroid | 3000 | PPRTV | 11/11/2014 |
| 7440-50-8 | Copper | chronic | 4.0E-02 | mg/kg/day | 1 | 4.0E-02 | mg/kg/day | GI | NA | HEAST | 11/11/2014 |
| 7439-89-6 | Iron | chronic | 7.0E-01 | mg/kg/day | 1 | 7.0E-01 | mg/kg/day | GI | 1.5 | PPRTV | 11/11/2014 |
| 7439-92-1 | Lead | NA | NA | mg/kg/day | 1 | NA | mg/kg/day | NA | NA | NA | 11/11/2014 |
| 7439-96-5 | Manganese | chronic | 1.4E-01 | mg/kg/day | 0.04 | 5.6E-03 | mg/kg/day | CNS | 1 | IRIS | 11/11/2014 |
| 7440-02-0 | Nickel | chronic | 2.0E-02 | mg/kg/day | 0.04 | 8.0E-04 | mg/kg/day | body weight | 300 | IRIS | 11/11/2014 |
| 7782-49-2 | Selenium | chronic | 5.0E-03 | mg/kg/day | 1 | 5.0E-03 | mg/kg/day | hair, nails, skin, blood, CNS | 3 | IRIS | 11/11/2014 |
| 7440-22-4 | Silver | chronic | 5.0E-03 | mg/kg/day | 0.04 | 2.0E-04 | mg/kg/day | skin | 3 | IRIS | 11/11/2014 |
| 7440-62-2 | Vanadium | NA | NA | mg/kg/day | 0.026 | NA | mg/kg/day | hair | 100 | IRIS | 11/11/2014 |
| 7440-66-6 | Zinc | NA | NA | mg/kg/day | 1 | NA | mg/kg/day | blood | 3 | NA | 11/11/2014 |

**Footnotes:**
(1) Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), July 2004, EPA/540/R/99/005. If not available, assumed to be 100%.
The absorbed dermal RfD is derived by multiplying the oral RfD by the oral absorption efficiency.
(2) Toxicity value for cadmium (water) used for cadmium; toxicity value for chromium VI used for chromium; toxicity value for manganese (non-diet) used for manganese; toxicity value for nitrite used for total nitrogen.
(3) Primary target(s) listed are those associated with the critical effect(s) on which the RfD was based.
(4) Date is the date the database was searched.
(5) Lead is evaluated separately using USEPA lead models.

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
Cal EPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Chronic Reference Exposure Levels (RELs); http://oehha.ca.gov/air/allrels.html
CAS = Chemical Abstract Service
CNS = central nervous system
GI = gastrointestinal tract
HEAST = Health Effect Assessment Summary Tables, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2877#Download
IRIS = Integrated Risk Information System; http://www.epa.gov/iris/

**Table 5.1**
**Non-Cancer Toxicity Data -- Oral and Dermal Pathways**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

mg/kg/day = milligrams per kilogram per day
NA= not available or not applicable
NR = none reported
PPRTV = Provisional Peer-Reviewed Toxicity Values; http://hhpprtv.ornl.gov
RfD = reference dose
WB = whole body

**Table 5.2**
**Non-Cancer Toxicity Data -- Inhalation Pathway**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| CAS Number | Chemical of Potential Concern (1),(4) | Chronic/ Subchronic | Inhalation RfC | | Primary Target Organ(s) (2) | Combined Uncertainty/Modifying Factors | RfC : Target Organ(s) | |
|---|---|---|---|---|---|---|---|---|
| | | | Value | Units | | | Source(s) (3) | Date(s) (MM/DD/YYYY) |
| **Volatile Organic Compounds (VOCs)** | | | | | | | | |
| 75-34-3 | 1,1-Dichloroethane | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 71-43-2 | Benzene | chronic | 3.0E-02 | $mg/m^3$ | immune system | 300 | IRIS | 11/11/2014 |
| 1634-04-4 | Methyl tert butyl ether | chronic | 3.0E+00 | $mg/m^3$ | liver, kidney | 100 | IRIS | 11/11/2014 |
| 108-88-3 | Toluene | chronic | 5.0E+00 | $mg/m^3$ | neurological | 10 | IRIS | 11/11/2014 |
| 79-01-6 | Trichloroethene | chronic | 2.0E-03 | $mg/m^3$ | heart, development, immune system | 10-100 | IRIS | 11/11/2014 |
| 1330-20-7 | Xylenes | NA | NA | $mg/m^3$ | CNS | 300 | NA | 11/11/2014 |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | |
| 117-81-7 | bis(2-Ethylhexyl)phthalate | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 91-20-3 | Naphthalene | chronic | 3.0E-03 | $mg/m^3$ | nasal | 3000 | IRIS | 11/11/2014 |
| **Metals - Total** | | | | | | | | |
| 7429-90-5 | Aluminum | chronic | 5.0E-03 | $mg/m^3$ | neurological | 300 | PPRTV | 11/11/2014 |
| 7440-38-2 | Arsenic | chronic | 1.5E-05 | $mg/m^3$ | developmental, neurobehavioral | 30 | CalEPA | 11/11/2014 |
| 7440-39-3 | Barium | chronic | 5.0E-04 | $mg/m^3$ | fetus | 1000 | HEAST | 11/11/2014 |
| 7440-43-9 | Cadmium | chronic | 1.0E-05 | $mg/m^3$ | kidney, respiratory system | 30 | ATSDR | 11/11/2014 |
| 18540-29-9 | Chromium | chronic | 8.0E-06 | $mg/m^3$ | nasal | 300 | IRIS | 11/11/2014 |
| 7440-48-4 | Cobalt | chronic | 6.0E-06 | $mg/m^3$ | lung | 300 | PPRTV | 11/11/2014 |
| 7440-50-8 | Copper | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 7439-89-6 | Iron | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 7439-92-1 | Lead | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 7439-96-5 | Manganese | chronic | 5.0E-05 | $mg/m^3$ | neurological | 1000 | IRIS | 11/11/2014 |
| 7440-02-0 | Nickel | chronic | 9.0E-05 | $mg/m^3$ | respiratory system | 30 | ATSDR | 11/11/2014 |
| 7782-49-2 | Selenium | chronic | 2.0E-02 | $mg/m^3$ | hair, nails, skin, blood, CNS | 3 | CalEPA | 11/11/2014 |
| 7440-22-4 | Silver | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 7440-62-2 | Vanadium | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |
| 7440-66-6 | Zinc | NA | NA | $mg/m^3$ | NA | NA | NA | 11/11/2014 |

**Footnotes:**
(1) Toxicity value for chromium VI used for chromium.
(2) Primary target(s) listed are those associated with the critical effect(s) on which the RfC was based.
(3) Date is the date the database was searched.
(4) Lead is evaluated separately using USEPA lead models.

**Table 5.2**
**Non-Cancer Toxicity Data -- Inhalation Pathway**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**Acronyms and Abbreviations:**

ATSDR = Agency for Toxic Substances & Disease Registry, Minimal Risk Levels, http://www.atsdr.cdc.gov/mrls/mrllist.asp
BHHRA = Baseline Human Health Risk Assessment
Cal EPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Inhalation Reference Exposure Levels, http://www.oehha.ca.gov/air/allrels.html
CAS = Chemical Abstract Service
CNS = central nervous system
HEAST = Health Effect Assessment Summary Tables, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2877#Download
IRIS = Integrated Risk Information System; http://www.epa.gov/iris/
$mg/m^3$ = milligrams per cubic meter
NA = not available or not applicable. If inhalation toxicity data are not available, toxicity will be discussed qualitatively.
PPRTV = Provisional Peer-Reviewed Toxicity Values; http://hhpprtv.ornl.gov
RfC = reference concentration

**Table 6.1**
**Cancer Toxicity Data -- Oral and Dermal Pathways**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| CAS Number | Chemical of Potential Concern (2) | Mutagen (3) | Oral Cancer Slope Factor | | Oral Absorption Efficiency for Dermal (1) | Absorbed Cancer Slope Factor for Dermal | | Weight of Evidence/ Cancer Guideline Description (4) | Oral CSF | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Value | Units | | Value (1) | Units | | Source(s) (5) | Date(s) (MM/DD/YYYY) |
| **Volatile Organic Compounds (VOCs)** | | | | | | | | | | |
| 75-34-3 | 1,1-Dichloroethane | | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | 1 | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | C | CalEPA | 11/11/2014 |
| 71-43-2 | Benzene | | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | 1 | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | A | IRIS | 11/11/2014 |
| 1634-04-4 | Methyl tert butyl ether | | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | 1 | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | NA | CalEPA | 11/11/2014 |
| 108-88-3 | Toluene | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |
| 79-01-6 | Trichloroethene | M | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | 1 | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | A | IRIS | 11/11/2014 |
| 1330-20-7 | Xylenes | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | |
| 117-81-7 | bis(2-Ethylhexyl)phthalate | | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | 1 | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | B2 | IRIS | 11/11/2014 |
| 91-20-3 | Naphthalene | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | C | NA | 11/11/2014 |
| **Metals - Total** | | | | | | | | | | |
| 7429-90-5 | Aluminum | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | 11/11/2014 |
| 7440-38-2 | Arsenic | | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | 1 | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | A | IRIS | 11/11/2014 |
| 7440-39-3 | Barium | | NA | $(mg/kg\text{-}day)^{-1}$ | 0.07 | NA | $(mg/kg\text{-}day)^{-1}$ | E/D | NA | 11/11/2014 |
| 7440-43-9 | Cadmium | | NA | $(mg/kg\text{-}day)^{-1}$ | 0.05 | NA | $(mg/kg\text{-}day)^{-1}$ | D/B1 | NA | 11/11/2014 |
| 18540-29-9 | Chromium | M | NA | $(mg/kg\text{-}day)^{-1}$ | 0.025 | NA | $(mg/kg\text{-}day)^{-1}$ | D/A | NA | 11/11/2014 |
| 7440-48-4 | Cobalt | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | B2 | NA | 11/11/2014 |
| 7440-50-8 | Copper | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |
| 7439-89-6 | Iron | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | 11/11/2014 |
| 7439-92-1 | Lead | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | B2 | NA | 11/11/2014 |
| 7439-96-5 | Manganese | | NA | $(mg/kg\text{-}day)^{-1}$ | 0.04 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |
| 7440-02-0 | Nickel | | NA | $(mg/kg\text{-}day)^{-1}$ | 0.04 | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | 11/11/2014 |
| 7782-49-2 | Selenium | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |
| 7440-22-4 | Silver | | NA | $(mg/kg\text{-}day)^{-1}$ | 0.04 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |
| 7440-62-2 | Vanadium | | NA | $(mg/kg\text{-}day)^{-1}$ | 0.026 | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | 11/11/2014 |
| 7440-66-6 | Zinc | | NA | $(mg/kg\text{-}day)^{-1}$ | 1 | NA | $(mg/kg\text{-}day)^{-1}$ | D | NA | 11/11/2014 |

**Footnotes:**

(1) Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), July 2004, EPA/540/R/99/005. If not available, assumed to be 100%. The dermal cancer slope factor is derived by dividing the oral CSF by the oral absorption efficiency.

(2) Toxicity value for chromium VI used for chromium.

(3) In accordance with USEPA guidance, constituents considered to have a mutagenic mode of action will be evaluated using the following age-dependent adjustment factors (ADAFs): for ages 0 - <2, ADAF = 10; for ages 2 - <16, ADAF=3; for ages ≥16, ADAF=1.

(4) USEPA (1986) cancer weight-of-evidence categories are as follows:
- Group A: Carcinogenic to Humans (sufficient evidence of carcinogenicity in humans)
- Group B: Probably Carcinogenic to Humans
  - B1 - limited evidence of carcinogenicity in humans
  - B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans
- Group C: Possibly Carcinogenic to Humans (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
- Group D: Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
- Group E: Evidence of Non-carcinogenicity for Humans

(5) Date is the date the database was searched.

**Table 6.1**
**Cancer Toxicity Data -- Oral and Dermal Pathways**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
Cal EPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Cancer Potency Values, http://www.oehha.ca.gov/risk/pdf/tcdb072109alpha.pdf
CAS = Chemical Abstract Service
CSF = cancer slope factor
IRIS = Integrated Risk Information System; http://www.epa.gov/iris/
M = mutagen
$(mg/kg/day)^{-1}$ = per milligram per kilogram per day
NA = not available or not applicable

**Table 6.2**
**Cancer Toxicity Data -- Inhalation Pathway**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| CAS Number | Chemical of Potential Concern (1) | Mutagen (2) | Unit Risk | | Weight of Evidence/ Cancer Guideline Description (3) | IUR | |
|---|---|---|---|---|---|---|---|
| | | | Value | Units | | Source(s) (4) | Date(s) (MM/DD/YYYY) |
| **Volatile Organic Compounds (VOCs)** | | | | | | | |
| 75-34-3 | 1,1-Dichloroethane | | 1.6E-06 | $(\mu g/m^3)^{-1}$ | C | CalEPA | 11/11/2014 |
| 71-43-2 | Benzene | | 7.8E-06 | $(\mu g/m^3)^{-1}$ | A | IRIS | 11/11/2014 |
| 1634-04-4 | Methyl tert butyl ether | | 2.6E-07 | $(\mu g/m^3)^{-1}$ | NA | CalEPA | 11/11/2014 |
| 108-88-3 | Toluene | | NA | $(\mu g/m^3)^{-1}$ | D | NA | 11/11/2014 |
| 79-01-6 | Trichloroethene | M | 4.1E-06 | $(\mu g/m^3)^{-1}$ | A | IRIS | 11/11/2014 |
| 1330-20-7 | Xylenes | | NA | $(\mu g/m^3)^{-1}$ | D | NA | 11/11/2014 |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | |
| 117-81-7 | bis(2-Ethylhexyl)phthalate | | 2.4E-06 | $(\mu g/m^3)^{-1}$ | B2 | CalEPA | 11/11/2014 |
| 91-20-3 | Naphthalene | | 3.4E-05 | $(\mu g/m^3)^{-1}$ | C | CalEPA | 11/11/2014 |
| **Metals - Total** | | | | | | | |
| 7429-90-5 | Aluminum | | NA | $(\mu g/m^3)^{-1}$ | NA | NA | 11/11/2014 |
| 7440-38-2 | Arsenic | | 4.3E-03 | $(\mu g/m^3)^{-1}$ | A | IRIS | 11/11/2014 |
| 7440-39-3 | Barium | | NA | $(\mu g/m^3)^{-1}$ | E/D | NA | 11/11/2014 |
| 7440-43-9 | Cadmium | | 1.8E-03 | $(\mu g/m^3)^{-1}$ | D/B1 | IRIS | 11/11/2014 |
| 18540-29-9 | Chromium | M | 1.2E-02 | $(\mu g/m^3)^{-1}$ | D/A | IRIS | 11/11/2014 |
| 7440-48-4 | Cobalt | | 9.0E-03 | $(\mu g/m^3)^{-1}$ | B2 | PPRTV | 11/11/2014 |
| 7440-50-8 | Copper | | NA | $(\mu g/m^3)^{-1}$ | D | NA | 11/11/2014 |
| 7439-89-6 | Iron | | NA | $(\mu g/m^3)^{-1}$ | NA | NA | 11/11/2014 |
| 7439-92-1 | Lead | | NA | $(\mu g/m^3)^{-1}$ | B2 | NA | 11/11/2014 |
| 7439-96-5 | Manganese | | NA | $(\mu g/m^3)^{-1}$ | D | NA | 11/11/2014 |
| 7440-02-0 | Nickel | | 2.6E-04 | $(\mu g/m^3)^{-1}$ | NA | CalEPA | 11/11/2014 |
| 7782-49-2 | Selenium | | NA | $(\mu g/m^3)^{-1}$ | D | NA | 11/11/2014 |
| 7440-22-4 | Silver | | NA | $(ug/m^3)^{-1}$ | D | NA | 11/11/2014 |
| 7440-62-2 | Vanadium | | NA | $(\mu g/m^3)^{-1}$ | NA | NA | 11/11/2014 |
| 7440-66-6 | Zinc | | NA | $(\mu g/m^3)^{-1}$ | D | NA | 11/11/2014 |

**Table 6.2**
**Cancer Toxicity Data -- Inhalation Pathway**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**Footnotes:**

(1) Toxicity value for chromium VI used for chromium.

(2) In accordance with USEPA guidance, constituents considered to have a mutagenic mode of action will be evaluated using the following age-dependent adjustment factors (ADAFs): for ages 0 - <2, ADAF = 10; for ages 2 - <16, ADAF=3; for ages ≥16, ADAF=1.

(3) USEPA (1986) cancer weight-of-evidence categories are as follows:

- Group A: Carcinogenic to Humans (sufficient evidence of carcinogenicity in humans)
- Group B: Probably Carcinogenic to Humans
  - B1 - limited evidence of carcinogenicity in humans
  - B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans
- Group C: Possibly Carcinogenic to Humans (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
- Group D: Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
- Group E: Evidence of Non-carcinogenicity for Humans

(4) Date is the date the database was searched.

**Acronyms and Abbreviations:**

BHHRA = Baseline Human Health Risk Assessment

Cal EPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Cancer Potency Values, http://www.oehha.ca.gov/risk/pdf/tcdb072109alpha.pdf

CAS = Chemical Abstract Service

IRIS = Integrated Risk Information System; http://www.epa.gov/iris/

IUR = inhalation unit risk

M = mutagen

NA = not available or not applicable. If inhalation toxicity data are not available, toxicity will be discussed qualitatively.

PPRTV = Provisional Peer-Reviewed Toxicity Values; http://hhpprtv.ornl.gov

$(\mu g/m^3)^{-1}$ = per microgram per cubic meter

**Table 7.1.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Ingestion | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | NA | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-01 | mg/kg-day | NA |
| | | | | Benzene | 1.5E+00 | µg/L | NA | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 4.0E-03 | mg/kg-day | NA |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | NA | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 8.0E-02 | mg/kg-day | NA |
| | | | | Trichloroethene | 2.6E-01 | µg/L | NA | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.0E-04 | mg/kg-day | NA |
| | | | | Xylenes | 2.9E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | NA | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-02 | mg/kg-day | NA |
| | | | | Naphthalene | 3.1E-01 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-02 | mg/kg-day | NA |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 1.0E+00 | mg/kg-day | NA |
| | | | | Arsenic | 2.8E+00 | µg/L | NA | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 3.0E-04 | mg/kg-day | NA |
| | | | | Barium | 9.4E+01 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-01 | mg/kg-day | NA |
| | | | | Cadmium | 4.2E-01 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.0E-04 | mg/kg-day | NA |
| | | | | Chromium | 4.3E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 3.0E-03 | mg/kg-day | NA |
| | | | | Cobalt | 2.6E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 3.0E-04 | mg/kg-day | NA |
| | | | | Copper | 7.1E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 4.0E-02 | mg/kg-day | NA |
| | | | | Iron | 1.2E+04 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 7.0E-01 | mg/kg-day | NA |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 1.4E-01 | mg/kg-day | NA |
| | | | | Nickel | 6.9E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-02 | mg/kg-day | NA |
| | | | | Selenium | 2.3E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.0E-03 | mg/kg-day | NA |
| | | | | Silver | 1.0E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.0E-03 | mg/kg-day | NA |
| | | | | Vanadium | 3.4E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 0E+00 | | | | | 0E+00 |

**Table 7.1.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC Value | EPC Units | Cancer Intake/Exposure Concentration Value | Cancer Intake/Exposure Concentration Units | CSF/Unit Risk Value | CSF/Unit Risk Units | Risk | Non-Cancer Intake/Exposure Concentration Value | Non-Cancer Intake/Exposure Concentration Units | RfD/RfC Value | RfD/RfC Units | Hazard Quotient |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Groundwater | Groundwater | Tap Water | Dermal | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | NA | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-01 | mg/kg-day | NA |
| | | | | Benzene | 1.5E+00 | µg/L | NA | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 4.0E-03 | mg/kg-day | NA |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | NA | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 8.0E-02 | mg/kg-day | NA |
| | | | | Trichloroethene | 2.6E-01 | µg/L | NA | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.0E-04 | mg/kg-day | NA |
| | | | | Xylenes | 2.9E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | NA | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-02 | mg/kg-day | NA |
| | | | | Naphthalene | 3.1E-01 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-02 | mg/kg-day | NA |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 1.0E+00 | mg/kg-day | NA |
| | | | | Arsenic | 2.8E+00 | µg/L | NA | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 3.0E-04 | mg/kg-day | NA |
| | | | | Barium | 9.4E+01 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 1.4E-02 | mg/kg-day | NA |
| | | | | Cadmium | 4.2E-01 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.5E-05 | mg/kg-day | NA |
| | | | | Chromium | 4.3E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 7.5E-05 | mg/kg-day | NA |
| | | | | Cobalt | 2.6E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 3.0E-04 | mg/kg-day | NA |
| | | | | Copper | 7.1E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 4.0E-02 | mg/kg-day | NA |
| | | | | Iron | 1.2E+04 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 7.0E-01 | mg/kg-day | NA |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.6E-03 | mg/kg-day | NA |
| | | | | Nickel | 6.9E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 8.0E-04 | mg/kg-day | NA |
| | | | | Selenium | 2.3E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 5.0E-03 | mg/kg-day | NA |
| | | | | Silver | 1.0E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | 2.0E-04 | mg/kg-day | NA |
| | | | | Vanadium | 3.4E+00 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 0E+00 | | | | | 0E+00 |
| | | Exposure Point Total | | | | | | | | | 0E+00 | | | | | 0E+00 |
| | Exposure Medium Total | | | | | | | | | | 0E+00 | | | | | 0E+00 |

**Table 7.1.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Receptor Population: Hypothetical Future Resident |
| Receptor Age: Adult |

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Air | Shower Air | Inhalation | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 2.9E+00 | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.6E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Benzene | 5.1E+00 | $\mu g/m^3$ | NA | $\mu g/m^3$ | 7.8E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 3.0E-02 | $mg/m^3$ | NA |
| | | | | Methyl tert butyl ether | 3.8E+00 | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.6E-07 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 3.0E+00 | $mg/m^3$ | NA |
| | | | | Toluene | 1.8E+01 | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E+00 | $mg/m^3$ | NA |
| | | | | Trichloroethene | 8.8E-01 | $\mu g/m^3$ | NA | $\mu g/m^3$ | 4.1E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 2.0E-03 | $mg/m^3$ | NA |
| | | | | Xylenes | 9.5E+00 | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.4E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Naphthalene | 8.7E-01 | $\mu g/m^3$ | NA | $\mu g/m^3$ | 3.4E-05 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 3.0E-03 | $mg/m^3$ | NA |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-03 | $mg/m^3$ | NA |
| | | | | Arsenic | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 4.3E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.5E-05 | $mg/m^3$ | NA |
| | | | | Barium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-04 | $mg/m^3$ | NA |
| | | | | Cadmium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.8E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.0E-05 | $mg/m^3$ | NA |
| | | | | Chromium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.2E-02 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 8.0E-06 | $mg/m^3$ | NA |
| | | | | Cobalt | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 9.0E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 6.0E-06 | $mg/m^3$ | NA |
| | | | | Copper | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Iron | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Lead | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Manganese | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-05 | $mg/m^3$ | NA |
| | | | | Nickel | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.6E-04 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 9.0E-05 | $mg/m^3$ | NA |
| | | | | Selenium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 2.0E-02 | $mg/m^3$ | NA |
| | | | | Silver | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Vanadium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Zinc | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | Exp. Route Total | | | | | | | | 0E+00 | | | | | 0E+00 |
| | | Exposure Point Total | | | | | | | | | 0E+00 | | | | | 0E+00 |
| | Exposure Medium Total | | | | | | | | | | 0E+00 | | | | | 0E+00 |
| Medium Total | | | | | | | | | | | 0E+00 | | | | | 0E+00 |
| Receptor Total | | | | | | | Total of Receptor Risks Across All Media | | | | 0E+00 | Total of Receptor Hazards Across All Media | | | | 0E+00 |

**Table 7.1.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |

**Footnotes:**
(1) The exposure duration (ED) for the hypothetical future adult resident under a central tendency (CT) scenario is set to 0 years (see Table 4.1.CT); therefore, risks and hazards are not calculated for this receptor.
**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
CSF = cancer slope factor
EPC = exposure point concentration
mg/kg/day = milligrams per kilogram per day
$(mg/kg/day)^{-1}$ = per milligram per kilogram per day
$mg/m^3$ = milligrams per cubic meter
NA = not available or not applicable
RfC = reference concentration
RfD = reference dose
µg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter
$(\mu g/m^3)^{-1}$ = per microgram per cubic meter

**Table 7.1.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Receptor Population: Hypothetical Future Resident |
| Receptor Age: Adult |

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Ingestion | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 1.2E-05 | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | 6.7E-08 | 2.3E-05 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.1E-04 |
| | | | | Benzene | 1.5E+00 | µg/L | 2.1E-05 | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | 1.2E-06 | 4.1E-05 | mg/kg-day | 4.0E-03 | mg/kg-day | 1.0E-02 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 1.9E-05 | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | 3.3E-08 | 3.6E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 8.1E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.6E-04 | mg/kg-day | 8.0E-02 | mg/kg-day | 2.0E-03 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 3.7E-06 | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | 1.7E-07 | 7.2E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 1.4E-02 |
| | | | | Xylenes | 2.9E+00 | µg/L | 4.1E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 7.9E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 2.2E-05 | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | 3.1E-07 | 4.3E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 2.2E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 4.4E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 8.5E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 4.3E-04 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 2.0E-02 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.9E-02 | mg/kg-day | 1.0E+00 | mg/kg-day | 3.9E-02 |
| | | | | Arsenic | 2.8E+00 | µg/L | 3.9E-05 | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | 5.9E-05 | 7.6E-05 | mg/kg-day | 3.0E-04 | mg/kg-day | 2.5E-01 |
| | | | | Barium | 9.4E+01 | µg/L | 1.3E-03 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.6E-03 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.3E-02 |
| | | | | Cadmium | 4.2E-01 | µg/L | 5.9E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.1E-05 | mg/kg-day | 5.0E-04 | mg/kg-day | 2.3E-02 |
| | | | | Chromium | 4.3E+00 | µg/L | 6.1E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.2E-04 | mg/kg-day | 3.0E-03 | mg/kg-day | 4.0E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 3.6E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 7.1E-05 | mg/kg-day | 3.0E-04 | mg/kg-day | 2.4E-01 |
| | | | | Copper | 7.1E+00 | µg/L | 1.0E-04 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.9E-04 | mg/kg-day | 4.0E-02 | mg/kg-day | 4.9E-03 |
| | | | | Iron | 1.2E+04 | µg/L | 1.7E-01 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.4E-01 | mg/kg-day | 7.0E-01 | mg/kg-day | 4.8E-01 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 2.6E-02 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 5.1E-02 | mg/kg-day | 1.4E-01 | mg/kg-day | 3.7E-01 |
| | | | | Nickel | 6.9E+00 | µg/L | 9.7E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.9E-04 | mg/kg-day | 2.0E-02 | mg/kg-day | 9.4E-03 |
| | | | | Selenium | 2.3E+00 | µg/L | 3.2E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.2E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 1.2E-02 |
| | | | | Silver | 1.0E+00 | µg/L | 1.5E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.8E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 5.7E-03 |
| | | | | Vanadium | 3.4E+00 | µg/L | 4.8E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 9.4E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 8.7E-03 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.7E-02 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 6E-05 | | | | | 2E+00 |

**Table 7.1.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Dermal | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 1.1E-06 | mg/kg-day | 5.7E-03 | (mg/kg-day)$^{-1}$ | 6.1E-09 | 2.1E-06 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.0E-05 |
| | | | | Benzene | 1.5E+00 | µg/L | 3.7E-06 | mg/kg-day | 5.5E-02 | (mg/kg-day)$^{-1}$ | 2.1E-07 | 7.3E-06 | mg/kg-day | 4.0E-03 | mg/kg-day | 1.8E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 5.0E-07 | mg/kg-day | 1.8E-03 | (mg/kg-day)$^{-1}$ | 8.9E-10 | 9.6E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 3.3E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.4E-05 | mg/kg-day | 8.0E-02 | mg/kg-day | 7.9E-04 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 7.2E-07 | mg/kg-day | 4.6E-02 | (mg/kg-day)$^{-1}$ | 3.3E-08 | 1.4E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 2.8E-03 |
| | | | | Xylenes | 2.9E+00 | µg/L | 2.9E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 5.6E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 4.0E-05 | mg/kg-day | 1.4E-02 | (mg/kg-day)$^{-1}$ | 5.6E-07 | 7.7E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 3.9E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 6.7E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.3E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 6.5E-05 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 1.3E-04 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.6E-04 | mg/kg-day | 1.0E+00 | mg/kg-day | 2.6E-04 |
| | | | | Arsenic | 2.8E+00 | µg/L | 2.6E-07 | mg/kg-day | 1.5E+00 | (mg/kg-day)$^{-1}$ | 3.8E-07 | 5.0E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 1.7E-03 |
| | | | | Barium | 9.4E+01 | µg/L | 8.7E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.7E-05 | mg/kg-day | 1.4E-02 | mg/kg-day | 1.2E-03 |
| | | | | Cadmium | 4.2E-01 | µg/L | 3.9E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 7.5E-08 | mg/kg-day | 2.5E-05 | mg/kg-day | 3.0E-03 |
| | | | | Chromium | 4.3E+00 | µg/L | 8.0E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.6E-06 | mg/kg-day | 7.5E-05 | mg/kg-day | 2.1E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 9.6E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.9E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 6.2E-04 |
| | | | | Copper | 7.1E+00 | µg/L | 6.6E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.3E-06 | mg/kg-day | 4.0E-02 | mg/kg-day | 3.2E-05 |
| | | | | Iron | 1.2E+04 | µg/L | 1.1E-03 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.2E-03 | mg/kg-day | 7.0E-01 | mg/kg-day | 3.2E-03 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 1.7E-04 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.4E-04 | mg/kg-day | 5.6E-03 | mg/kg-day | 6.0E-02 |
| | | | | Nickel | 6.9E+00 | µg/L | 1.3E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.5E-07 | mg/kg-day | 8.0E-04 | mg/kg-day | 3.1E-04 |
| | | | | Selenium | 2.3E+00 | µg/L | 2.1E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.1E-07 | mg/kg-day | 5.0E-03 | mg/kg-day | 8.1E-05 |
| | | | | Silver | 1.0E+00 | µg/L | 9.6E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.9E-07 | mg/kg-day | 2.0E-04 | mg/kg-day | 9.4E-04 |
| | | | | Vanadium | 3.4E+00 | µg/L | 3.2E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.1E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 3.4E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.7E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 1E-06 | | | | | 1E-01 |
| | | Exposure Point Total | | | | | | | | | 6E-05 | | | | | 2E+00 |
| | Exposure Medium Total | | | | | | | | | | 6E-05 | | | | | 2E+00 |

**Table 7.1.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Adult**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC Value | EPC Units | Cancer Risk Calculations: Intake/Exposure Concentration Value | Intake/Exposure Concentration Units | CSF/Unit Risk Value | CSF/Unit Risk Units | Risk | Non-Cancer Hazard Calculations: Intake/Exposure Concentration Value | Intake/Exposure Concentration Units | RfD/RfC Value | RfD/RfC Units | Hazard Quotient |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Groundwater | Air | Shower Air | Inhalation | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.6E+00 | μg/m$^3$ | 1.6E-01 | μg/m$^3$ | 1.6E-06 | (μg/m$^3$)$^{-1}$ | 2.6E-07 | 3.2E-01 | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Benzene | 1.5E+01 | μg/m$^3$ | 2.9E-01 | μg/m$^3$ | 7.8E-06 | (μg/m$^3$)$^{-1}$ | 2.3E-06 | 5.6E-01 | μg/m$^3$ | 3.0E-02 | mg/m$^3$ | 1.9E-02 |
| | | | | Methyl tert butyl ether | 1.1E+01 | μg/m$^3$ | 2.2E-01 | μg/m$^3$ | 2.6E-07 | (μg/m$^3$)$^{-1}$ | 5.6E-08 | 4.2E-01 | μg/m$^3$ | 3.0E+00 | mg/m$^3$ | 1.4E-04 |
| | | | | Toluene | 5.4E+01 | μg/m$^3$ | 1.0E+00 | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | 2.0E+00 | μg/m$^3$ | 5.0E+00 | mg/m$^3$ | 4.0E-04 |
| | | | | Trichloroethene | 2.7E+00 | μg/m$^3$ | 5.1E-02 | μg/m$^3$ | 4.1E-06 | (μg/m$^3$)$^{-1}$ | 2.1E-07 | 9.8E-02 | μg/m$^3$ | 2.0E-03 | mg/m$^3$ | 4.9E-02 |
| | | | | Xylenes | 2.9E+01 | μg/m$^3$ | 5.4E-01 | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | 1.1E+00 | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | NA | μg/m$^3$ | NA | μg/m$^3$ | 2.4E-06 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Naphthalene | 2.6E+00 | μg/m$^3$ | 5.0E-02 | μg/m$^3$ | 3.4E-05 | (μg/m$^3$)$^{-1}$ | 1.7E-06 | 9.7E-02 | μg/m$^3$ | 3.0E-03 | mg/m$^3$ | 3.2E-02 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 5.0E-03 | mg/m$^3$ | NA |
| | | | | Arsenic | NA | μg/m$^3$ | NA | μg/m$^3$ | 4.3E-03 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 1.5E-05 | mg/m$^3$ | NA |
| | | | | Barium | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 5.0E-04 | mg/m$^3$ | NA |
| | | | | Cadmium | NA | μg/m$^3$ | NA | μg/m$^3$ | 1.8E-03 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 1.0E-05 | mg/m$^3$ | NA |
| | | | | Chromium | NA | μg/m$^3$ | NA | μg/m$^3$ | 1.2E-02 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 8.0E-06 | mg/m$^3$ | NA |
| | | | | Cobalt | NA | μg/m$^3$ | NA | μg/m$^3$ | 9.0E-03 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 6.0E-06 | mg/m$^3$ | NA |
| | | | | Copper | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Iron | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Lead | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Manganese | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 5.0E-05 | mg/m$^3$ | NA |
| | | | | Nickel | NA | μg/m$^3$ | NA | μg/m$^3$ | 2.6E-04 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 9.0E-05 | mg/m$^3$ | NA |
| | | | | Selenium | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 2.0E-02 | mg/m$^3$ | NA |
| | | | | Silver | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Vanadium | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Zinc | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | Exp. Route Total | | | | | | | | 4E-06 | | | | | 1E-01 |
| | | Exposure Point Total | | | | | | | | | 4E-06 | | | | | 1E-01 |
| | Exposure Medium Total | | | | | | | | | | 4E-06 | | | | | 1E-01 |
| Medium Total | | | | | | | | | | | 7E-05 | | | | | 2E+00 |
| Receptor Total | | | | | | | | | Total of Receptor Risks Across All Media | | 7E-05 | Total of Receptor Hazards Across All Media | | | | 2E+00 |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
CSF = cancer slope factor
EPC = exposure point concentration
mg/kg/day = milligrams per kilogram per day
(mg/kg/day)$^{-1}$ = per milligram per kilogram per day
mg/m$^3$ = milligrams per cubic meter
NA = not available or not applicable
RfC = reference concentration
RfD = reference dose
μg/L = micrograms per liter
μg/m$^3$ = micrograms per cubic meter
(μg/m$^3$)$^{-1}$ = per microgram per cubic meter

**Table 7.2.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Youth**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Ingestion | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 3.6E-07 | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | 2.1E-09 | 8.5E-06 | mg/kg-day | 2.0E-01 | mg/kg-day | 4.2E-05 |
| | | | | Benzene | 1.5E+00 | µg/L | 6.6E-07 | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | 3.6E-08 | 1.5E-05 | mg/kg-day | 4.0E-03 | mg/kg-day | 3.8E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 5.8E-07 | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | 1.0E-09 | 1.3E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 2.5E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 5.9E-05 | mg/kg-day | 8.0E-02 | mg/kg-day | 7.3E-04 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 3.5E-07 | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | 1.6E-08 | 2.7E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 5.4E-03 |
| | | | | Xylenes | 2.9E+00 | µg/L | 1.3E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.9E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 6.9E-07 | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | 9.7E-09 | 1.6E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 8.0E-04 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 1.4E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.2E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 1.6E-04 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 6.2E-04 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.5E-02 | mg/kg-day | 1.0E+00 | mg/kg-day | 1.5E-02 |
| | | | | Arsenic | 2.8E+00 | µg/L | 1.2E-06 | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | 1.8E-06 | 2.8E-05 | mg/kg-day | 3.0E-04 | mg/kg-day | 9.4E-02 |
| | | | | Barium | 9.4E+01 | µg/L | 4.1E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 9.6E-04 | mg/kg-day | 2.0E-01 | mg/kg-day | 4.8E-03 |
| | | | | Cadmium | 4.2E-01 | µg/L | 1.8E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 4.3E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 8.5E-03 |
| | | | | Chromium | 4.3E+00 | µg/L | 5.7E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 4.4E-05 | mg/kg-day | 3.0E-03 | mg/kg-day | 1.5E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 1.1E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.6E-05 | mg/kg-day | 3.0E-04 | mg/kg-day | 8.8E-02 |
| | | | | Copper | 7.1E+00 | µg/L | 3.1E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 7.3E-05 | mg/kg-day | 4.0E-02 | mg/kg-day | 1.8E-03 |
| | | | | Iron | 1.2E+04 | µg/L | 5.4E-03 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.3E-01 | mg/kg-day | 7.0E-01 | mg/kg-day | 1.8E-01 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 8.2E-04 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.9E-02 | mg/kg-day | 1.4E-01 | mg/kg-day | 1.4E-01 |
| | | | | Nickel | 6.9E+00 | µg/L | 3.0E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 7.1E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 3.5E-03 |
| | | | | Selenium | 2.3E+00 | µg/L | 9.9E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.3E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 4.6E-03 |
| | | | | Silver | 1.0E+00 | µg/L | 4.6E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.1E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 2.1E-03 |
| | | | | Vanadium | 3.4E+00 | µg/L | 1.5E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.5E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 2.7E-04 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.3E-03 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 2E-06 | | | | | 6E-01 |

**Table 7.2.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Youth**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Receptor Population: Hypothetical Future Resident |
| Receptor Age: Youth |

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC Value | EPC Units | Cancer Risk Calculations: Intake/Exposure Concentration Value | Intake/Exposure Concentration Units | CSF/Unit Risk Value | CSF/Unit Risk Units | Risk | Non-Cancer Hazard Calculations: Intake/Exposure Concentration Value | Intake/Exposure Concentration Units | RfD/RfC Value | RfD/RfC Units | Hazard Quotient |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Groundwater | Groundwater | Tap Water | Dermal | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 6.7E-08 | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | 3.8E-10 | 1.6E-06 | mg/kg-day | 2.0E-01 | mg/kg-day | 7.8E-06 |
| | | | | Benzene | 1.5E+00 | µg/L | 2.3E-07 | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | 1.3E-08 | 5.4E-06 | mg/kg-day | 4.0E-03 | mg/kg-day | 1.4E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 3.1E-08 | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | 5.6E-11 | 7.2E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 2.0E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 4.8E-05 | mg/kg-day | 8.0E-02 | mg/kg-day | 5.9E-04 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 1.3E-07 | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | 6.2E-09 | 1.0E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 2.1E-03 |
| | | | | Xylenes | 2.9E+00 | µg/L | 1.8E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 4.2E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 2.5E-06 | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | 3.5E-08 | 5.8E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 2.9E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 4.2E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 9.7E-07 | mg/kg-day | 2.0E-02 | mg/kg-day | 4.9E-05 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 5.5E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.3E-04 | mg/kg-day | 1.0E+00 | mg/kg-day | 1.3E-04 |
| | | | | Arsenic | 2.8E+00 | µg/L | 1.1E-08 | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | 1.6E-08 | 2.5E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 8.3E-04 |
| | | | | Barium | 9.4E+01 | µg/L | 3.6E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 8.4E-06 | mg/kg-day | 1.4E-02 | mg/kg-day | 6.0E-04 |
| | | | | Cadmium | 4.2E-01 | µg/L | 1.6E-09 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.8E-08 | mg/kg-day | 2.5E-05 | mg/kg-day | 1.5E-03 |
| | | | | Chromium | 4.3E+00 | µg/L | 1.0E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 7.8E-07 | mg/kg-day | 7.5E-05 | mg/kg-day | 1.0E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 4.0E-09 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 9.3E-08 | mg/kg-day | 3.0E-04 | mg/kg-day | 3.1E-04 |
| | | | | Copper | 7.1E+00 | µg/L | 2.7E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.4E-07 | mg/kg-day | 4.0E-02 | mg/kg-day | 1.6E-05 |
| | | | | Iron | 1.2E+04 | µg/L | 4.8E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.1E-03 | mg/kg-day | 7.0E-01 | mg/kg-day | 1.6E-03 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 7.3E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.7E-04 | mg/kg-day | 5.6E-03 | mg/kg-day | 3.0E-02 |
| | | | | Nickel | 6.9E+00 | µg/L | 5.3E-09 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.2E-07 | mg/kg-day | 8.0E-04 | mg/kg-day | 1.6E-04 |
| | | | | Selenium | 2.3E+00 | µg/L | 8.7E-09 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.0E-07 | mg/kg-day | 5.0E-03 | mg/kg-day | 4.1E-05 |
| | | | | Silver | 1.0E+00 | µg/L | 4.0E-09 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 9.4E-08 | mg/kg-day | 2.0E-04 | mg/kg-day | 4.7E-04 |
| | | | | Vanadium | 3.4E+00 | µg/L | 1.3E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.1E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 1.4E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.4E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 7E-08 | | | | | 5E-02 |
| | | Exposure Point Total | | | | | | | | | 2E-06 | | | | | 6E-01 |
| | Exposure Medium Total | | | | | | | | | | 2E-06 | | | | | 6E-01 |

**Table 7.2.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Youth**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Receptor Population: Hypothetical Future Resident |
| Receptor Age: Youth |

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Air | Shower Air | Inhalation | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 2.6E+00 | $\mu g/m^3$ | 1.9E-03 | $\mu g/m^3$ | 1.6E-06 | $(\mu g/m^3)^{-1}$ | 3.0E-09 | 4.4E-02 | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Benzene | 4.6E+00 | $\mu g/m^3$ | 3.3E-03 | $\mu g/m^3$ | 7.8E-06 | $(\mu g/m^3)^{-1}$ | 2.6E-08 | 7.7E-02 | $\mu g/m^3$ | 3.0E-02 | $mg/m^3$ | 2.6E-03 |
| | | | | Methyl tert butyl ether | 3.5E+00 | $\mu g/m^3$ | 2.5E-03 | $\mu g/m^3$ | 2.6E-07 | $(\mu g/m^3)^{-1}$ | 6.5E-10 | 5.8E-02 | $\mu g/m^3$ | 3.0E+00 | $mg/m^3$ | 1.9E-05 |
| | | | | Toluene | 1.6E+01 | $\mu g/m^3$ | 1.2E-02 | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | 2.8E-01 | $\mu g/m^3$ | 5.0E+00 | $mg/m^3$ | 5.5E-05 |
| | | | | Trichloroethene | 8.1E-01 | $\mu g/m^3$ | 1.7E-03 | $\mu g/m^3$ | 4.1E-06 | $(\mu g/m^3)^{-1}$ | 7.1E-09 | 1.4E-02 | $\mu g/m^3$ | 2.0E-03 | $mg/m^3$ | 6.8E-03 |
| | | | | Xylenes | 8.6E+00 | $\mu g/m^3$ | 6.2E-03 | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | 1.4E-01 | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.4E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Naphthalene | 7.9E-01 | $\mu g/m^3$ | 5.7E-04 | $\mu g/m^3$ | 3.4E-05 | $(\mu g/m^3)^{-1}$ | 1.9E-08 | 1.3E-02 | $\mu g/m^3$ | 3.0E-03 | $mg/m^3$ | 4.4E-03 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-03 | $mg/m^3$ | NA |
| | | | | Arsenic | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 4.3E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.5E-05 | $mg/m^3$ | NA |
| | | | | Barium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-04 | $mg/m^3$ | NA |
| | | | | Cadmium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.8E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.0E-05 | $mg/m^3$ | NA |
| | | | | Chromium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.2E-02 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 8.0E-06 | $mg/m^3$ | NA |
| | | | | Cobalt | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 9.0E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 6.0E-06 | $mg/m^3$ | NA |
| | | | | Copper | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Iron | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Lead | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Manganese | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-05 | $mg/m^3$ | NA |
| | | | | Nickel | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.6E-04 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 9.0E-05 | $mg/m^3$ | NA |
| | | | | Selenium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 2.0E-02 | $mg/m^3$ | NA |
| | | | | Silver | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Vanadium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Zinc | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | Exp. Route Total | | | | | | | | 6E-08 | | | | | 1E-02 |
| | | Exposure Point Total | | | | | | | | | 6E-08 | | | | | 1E-02 |
| | Exposure Medium Total | | | | | | | | | | 6E-08 | | | | | 1E-02 |
| Medium Total | | | | | | | | | | | 2E-06 | | | | | 6E-01 |
| Receptor Total | | | | | | | Total of Receptor Risks Across All Media | | | | 2E-06 | Total of Receptor Hazards Across All Media | | | | 6E-01 |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
CSF = cancer slope factor
EPC = exposure point concentration
mg/kg/day = milligrams per kilogram per day
$(mg/kg/day)^{-1}$ = per milligram per kilogram per day
$mg/m^3$ = milligrams per cubic meter
NA = not available or not applicable
RfC = reference concentration
RfD = reference dose
μg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter
$(\mu g/m^3)^{-1}$ = per microgram per cubic meter

**Table 7.2.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Youth**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Ingestion | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 5.1E-06 | mg/kg-day | 5.7E-03 | (mg/kg-day)$^{-1}$ | 2.9E-08 | 3.5E-05 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.8E-04 |
| | | | | Benzene | 1.5E+00 | µg/L | 9.1E-06 | mg/kg-day | 5.5E-02 | (mg/kg-day)$^{-1}$ | 5.0E-07 | 6.4E-05 | mg/kg-day | 4.0E-03 | mg/kg-day | 1.6E-02 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 8.0E-06 | mg/kg-day | 1.8E-03 | (mg/kg-day)$^{-1}$ | 1.4E-08 | 5.6E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 3.5E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.4E-04 | mg/kg-day | 8.0E-02 | mg/kg-day | 3.1E-03 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 4.5E-06 | mg/kg-day | 4.6E-02 | (mg/kg-day)$^{-1}$ | 2.1E-07 | 1.1E-05 | mg/kg-day | 5.0E-04 | mg/kg-day | 2.2E-02 |
| | | | | Xylenes | 2.9E+00 | µg/L | 1.8E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.2E-04 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 9.6E-06 | mg/kg-day | 1.4E-02 | (mg/kg-day)$^{-1}$ | 1.3E-07 | 6.7E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 3.4E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 1.9E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.3E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 6.6E-04 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 8.6E-03 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.0E-02 | mg/kg-day | 1.0E+00 | mg/kg-day | 6.0E-02 |
| | | | | Arsenic | 2.8E+00 | µg/L | 1.7E-05 | mg/kg-day | 1.5E+00 | (mg/kg-day)$^{-1}$ | 2.5E-05 | 1.2E-04 | mg/kg-day | 3.0E-04 | mg/kg-day | 3.9E-01 |
| | | | | Barium | 9.4E+01 | µg/L | 5.7E-04 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.0E-03 | mg/kg-day | 2.0E-01 | mg/kg-day | 2.0E-02 |
| | | | | Cadmium | 4.2E-01 | µg/L | 2.5E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.8E-05 | mg/kg-day | 5.0E-04 | mg/kg-day | 3.5E-02 |
| | | | | Chromium | 4.3E+00 | µg/L | 7.4E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.8E-04 | mg/kg-day | 3.0E-03 | mg/kg-day | 6.2E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 1.6E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.1E-04 | mg/kg-day | 3.0E-04 | mg/kg-day | 3.7E-01 |
| | | | | Copper | 7.1E+00 | µg/L | 4.3E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.0E-04 | mg/kg-day | 4.0E-02 | mg/kg-day | 7.6E-03 |
| | | | | Iron | 1.2E+04 | µg/L | 7.5E-02 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 5.3E-01 | mg/kg-day | 7.0E-01 | mg/kg-day | 7.5E-01 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 1.1E-02 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 8.0E-02 | mg/kg-day | 1.4E-01 | mg/kg-day | 5.7E-01 |
| | | | | Nickel | 6.9E+00 | µg/L | 4.2E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.9E-04 | mg/kg-day | 2.0E-02 | mg/kg-day | 1.5E-02 |
| | | | | Selenium | 2.3E+00 | µg/L | 1.4E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 9.6E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 1.9E-02 |
| | | | | Silver | 1.0E+00 | µg/L | 6.3E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.4E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 8.9E-03 |
| | | | | Vanadium | 3.4E+00 | µg/L | 2.1E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.5E-04 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 3.8E-03 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.6E-02 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 3E-05 | | | | | 2E+00 |

**Table 7.2.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Youth**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Dermal | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 2.9E-07 | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | 1.7E-09 | 2.1E-06 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.0E-05 |
| | | | | Benzene | 1.5E+00 | µg/L | 1.0E-06 | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | 5.6E-08 | 7.2E-06 | mg/kg-day | 4.0E-03 | mg/kg-day | 1.8E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 1.4E-07 | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | 2.4E-10 | 9.5E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 9.0E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.3E-05 | mg/kg-day | 8.0E-02 | mg/kg-day | 7.8E-04 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 5.5E-07 | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | 2.5E-08 | 1.4E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 2.8E-03 |
| | | | | Xylenes | 2.9E+00 | µg/L | 7.9E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 5.5E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 1.1E-05 | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | 1.5E-07 | 7.6E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 3.8E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 1.8E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.3E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 6.4E-05 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 3.2E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.2E-04 | mg/kg-day | 1.0E+00 | mg/kg-day | 2.2E-04 |
| | | | | Arsenic | 2.8E+00 | µg/L | 6.2E-08 | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | 9.3E-08 | 4.3E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 1.4E-03 |
| | | | | Barium | 9.4E+01 | µg/L | 2.1E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.5E-05 | mg/kg-day | 1.4E-02 | mg/kg-day | 1.0E-03 |
| | | | | Cadmium | 4.2E-01 | µg/L | 9.3E-09 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.5E-08 | mg/kg-day | 2.5E-05 | mg/kg-day | 2.6E-03 |
| | | | | Chromium | 4.3E+00 | µg/L | 5.4E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.4E-06 | mg/kg-day | 7.5E-05 | mg/kg-day | 1.8E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 2.3E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.6E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 5.4E-04 |
| | | | | Copper | 7.1E+00 | µg/L | 1.6E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.1E-06 | mg/kg-day | 4.0E-02 | mg/kg-day | 2.8E-05 |
| | | | | Iron | 1.2E+04 | µg/L | 2.8E-04 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.9E-03 | mg/kg-day | 7.0E-01 | mg/kg-day | 2.8E-03 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 4.2E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.9E-04 | mg/kg-day | 5.6E-03 | mg/kg-day | 5.2E-02 |
| | | | | Nickel | 6.9E+00 | µg/L | 3.1E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.2E-07 | mg/kg-day | 8.0E-04 | mg/kg-day | 2.7E-04 |
| | | | | Selenium | 2.3E+00 | µg/L | 5.0E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.5E-07 | mg/kg-day | 5.0E-03 | mg/kg-day | 7.0E-05 |
| | | | | Silver | 1.0E+00 | µg/L | 2.3E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.6E-07 | mg/kg-day | 2.0E-04 | mg/kg-day | 8.1E-04 |
| | | | | Vanadium | 3.4E+00 | µg/L | 7.6E-08 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 5.3E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 8.3E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 5.8E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 3E-07 | | | | | 9E-02 |
| | | Exposure Point Total | | | | | | | | | 3E-05 | | | | | 2E+00 |
| | Exposure Medium Total | | | | | | | | | | 3E-05 | | | | | 2E+00 |

**Table 7.2.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Youth**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Air | Shower Air | Inhalation | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 7.1E+00 | $\mu g/m^3$ | 3.2E-02 | $\mu g/m^3$ | 1.6E-06 | $(\mu g/m^3)^{-1}$ | 5.1E-08 | 2.2E-01 | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Benzene | 1.3E+01 | $\mu g/m^3$ | 5.6E-02 | $\mu g/m^3$ | 7.8E-06 | $(\mu g/m^3)^{-1}$ | 4.4E-07 | 3.9E-01 | $\mu g/m^3$ | 3.0E-02 | $mg/m^3$ | 1.3E-02 |
| | | | | Methyl tert butyl ether | 9.4E+00 | $\mu g/m^3$ | 4.2E-02 | $\mu g/m^3$ | 2.6E-07 | $(\mu g/m^3)^{-1}$ | 1.1E-08 | 3.0E-01 | $\mu g/m^3$ | 3.0E+00 | $mg/m^3$ | 9.9E-05 |
| | | | | Toluene | 4.4E+01 | $\mu g/m^3$ | 2.0E-01 | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | 1.4E+00 | $\mu g/m^3$ | 5.0E+00 | $mg/m^3$ | 2.8E-04 |
| | | | | Trichloroethene | 2.2E+00 | $\mu g/m^3$ | 2.8E-02 | $\mu g/m^3$ | 4.1E-06 | $(\mu g/m^3)^{-1}$ | 1.1E-07 | 6.9E-02 | $\mu g/m^3$ | 2.0E-03 | $mg/m^3$ | 3.5E-02 |
| | | | | Xylenes | 2.3E+01 | $\mu g/m^3$ | 1.1E-01 | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | 7.4E-01 | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.4E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Naphthalene | 2.2E+00 | $\mu g/m^3$ | 9.7E-03 | $\mu g/m^3$ | 3.4E-05 | $(\mu g/m^3)^{-1}$ | 3.3E-07 | 6.8E-02 | $\mu g/m^3$ | 3.0E-03 | $mg/m^3$ | 2.3E-02 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-03 | $mg/m^3$ | NA |
| | | | | Arsenic | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 4.3E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.5E-05 | $mg/m^3$ | NA |
| | | | | Barium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-04 | $mg/m^3$ | NA |
| | | | | Cadmium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.8E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.0E-05 | $mg/m^3$ | NA |
| | | | | Chromium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.2E-02 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 8.0E-06 | $mg/m^3$ | NA |
| | | | | Cobalt | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 9.0E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 6.0E-06 | $mg/m^3$ | NA |
| | | | | Copper | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Iron | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Lead | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Manganese | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-05 | $mg/m^3$ | NA |
| | | | | Nickel | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.6E-04 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 9.0E-05 | $mg/m^3$ | NA |
| | | | | Selenium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 2.0E-02 | $mg/m^3$ | NA |
| | | | | Silver | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Vanadium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Zinc | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | Exp. Route Total | | | | | | | | 9E-07 | | | | | 7E-02 |
| | | Exposure Point Total | | | | | | | | | 9E-07 | | | | | 7E-02 |
| | Exposure Medium Total | | | | | | | | | | 9E-07 | | | | | 7E-02 |
| Medium Total | | | | | | | | | | | 3E-05 | | | | | 3E+00 |
| Receptor Total | | | | | | | Total of Receptor Risks Across All Media | | | | 3E-05 | Total of Receptor Hazards Across All Media | | | | 3E+00 |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
CSF = cancer slope factor
EPC = exposure point concentration
mg/kg/day = milligrams per kilogram per day
$(mg/kg/day)^{-1}$ = per milligram per kilogram per day
$mg/m^3$ = milligrams per cubic meter
NA = not available or not applicable
RfC = reference concentration
RfD = reference dose
μg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter
$(\mu g/m^3)^{-1}$ = per microgram per cubic meter

**Table 7.3.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Ingestion | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 1.5E-06 | mg/kg-day | 5.7E-03 | $(mg/kg\text{-}day)^{-1}$ | 8.6E-09 | 1.8E-05 | mg/kg-day | 2.0E-01 | mg/kg-day | 8.8E-05 |
| | | | | Benzene | 1.5E+00 | µg/L | 2.7E-06 | mg/kg-day | 5.5E-02 | $(mg/kg\text{-}day)^{-1}$ | 1.5E-07 | 3.2E-05 | mg/kg-day | 4.0E-03 | mg/kg-day | 7.9E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 2.4E-06 | mg/kg-day | 1.8E-03 | $(mg/kg\text{-}day)^{-1}$ | 4.3E-09 | 2.8E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 1.0E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.2E-04 | mg/kg-day | 8.0E-02 | mg/kg-day | 1.5E-03 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 2.0E-06 | mg/kg-day | 4.6E-02 | $(mg/kg\text{-}day)^{-1}$ | 9.1E-08 | 5.5E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 1.1E-02 |
| | | | | Xylenes | 2.9E+00 | µg/L | 5.2E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.1E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 2.8E-06 | mg/kg-day | 1.4E-02 | $(mg/kg\text{-}day)^{-1}$ | 4.0E-08 | 3.3E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 1.7E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 5.6E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 6.6E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 3.3E-04 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 2.6E-03 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 3.0E-02 | mg/kg-day | 1.0E+00 | mg/kg-day | 3.0E-02 |
| | | | | Arsenic | 2.8E+00 | µg/L | 5.0E-06 | mg/kg-day | 1.5E+00 | $(mg/kg\text{-}day)^{-1}$ | 7.5E-06 | 5.8E-05 | mg/kg-day | 3.0E-04 | mg/kg-day | 1.9E-01 |
| | | | | Barium | 9.4E+01 | µg/L | 1.7E-04 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.0E-03 | mg/kg-day | 2.0E-01 | mg/kg-day | 9.9E-03 |
| | | | | Cadmium | 4.2E-01 | µg/L | 7.5E-07 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 8.8E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 1.8E-02 |
| | | | | Chromium | 4.3E+00 | µg/L | 3.3E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 9.2E-05 | mg/kg-day | 3.0E-03 | mg/kg-day | 3.1E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 4.7E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 5.5E-05 | mg/kg-day | 3.0E-04 | mg/kg-day | 1.8E-01 |
| | | | | Copper | 7.1E+00 | µg/L | 1.3E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.5E-04 | mg/kg-day | 4.0E-02 | mg/kg-day | 3.8E-03 |
| | | | | Iron | 1.2E+04 | µg/L | 2.2E-02 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.6E-01 | mg/kg-day | 7.0E-01 | mg/kg-day | 3.7E-01 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 3.4E-03 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 4.0E-02 | mg/kg-day | 1.4E-01 | mg/kg-day | 2.8E-01 |
| | | | | Nickel | 6.9E+00 | µg/L | 1.2E-05 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.5E-04 | mg/kg-day | 2.0E-02 | mg/kg-day | 7.3E-03 |
| | | | | Selenium | 2.3E+00 | µg/L | 4.1E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 4.7E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 9.5E-03 |
| | | | | Silver | 1.0E+00 | µg/L | 1.9E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 2.2E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 4.4E-03 |
| | | | | Vanadium | 3.4E+00 | µg/L | 6.2E-06 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 7.2E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 1.1E-03 | mg/kg-day | NA | $(mg/kg\text{-}day)^{-1}$ | NA | 1.3E-02 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 8E-06 | | | | | 1E+00 |

**Table 7.3.CT**

**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Young Child**

**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**

**Ringwood Mines/Landfill Superfund Site**

**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Dermal | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 2.2E-07 | mg/kg-day | 5.7E-03 | (mg/kg-day)$^{-1}$ | 1.2E-09 | 2.5E-06 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.3E-05 |
| | | | | Benzene | 1.5E+00 | µg/L | 7.6E-07 | mg/kg-day | 5.5E-02 | (mg/kg-day)$^{-1}$ | 4.2E-08 | 8.8E-06 | mg/kg-day | 4.0E-03 | mg/kg-day | 2.2E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 1.0E-07 | mg/kg-day | 1.8E-03 | (mg/kg-day)$^{-1}$ | 1.8E-10 | 1.2E-06 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 6.6E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 7.7E-05 | mg/kg-day | 8.0E-02 | mg/kg-day | 9.6E-04 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 6.1E-07 | mg/kg-day | 4.6E-02 | (mg/kg-day)$^{-1}$ | 2.8E-08 | 1.7E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 3.4E-03 |
| | | | | Xylenes | 2.9E+00 | µg/L | 5.8E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.8E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 8.0E-06 | mg/kg-day | 1.4E-02 | (mg/kg-day)$^{-1}$ | 1.1E-07 | 9.4E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 4.7E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 1.4E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.6E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 7.9E-05 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 1.8E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.1E-04 | mg/kg-day | 1.0E+00 | mg/kg-day | 2.1E-04 |
| | | | | Arsenic | 2.8E+00 | µg/L | 3.5E-08 | mg/kg-day | 1.5E+00 | (mg/kg-day)$^{-1}$ | 5.3E-08 | 4.1E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 1.4E-03 |
| | | | | Barium | 9.4E+01 | µg/L | 1.2E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.4E-05 | mg/kg-day | 1.4E-02 | mg/kg-day | 9.9E-04 |
| | | | | Cadmium | 4.2E-01 | µg/L | 5.3E-09 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.2E-08 | mg/kg-day | 2.5E-05 | mg/kg-day | 2.5E-03 |
| | | | | Chromium | 4.3E+00 | µg/L | 4.6E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.3E-06 | mg/kg-day | 7.5E-05 | mg/kg-day | 1.7E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 1.3E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.5E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 5.1E-04 |
| | | | | Copper | 7.1E+00 | µg/L | 9.1E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.1E-06 | mg/kg-day | 4.0E-02 | mg/kg-day | 2.6E-05 |
| | | | | Iron | 1.2E+04 | µg/L | 1.6E-04 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.8E-03 | mg/kg-day | 7.0E-01 | mg/kg-day | 2.6E-03 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 2.4E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.8E-04 | mg/kg-day | 5.6E-03 | mg/kg-day | 5.0E-02 |
| | | | | Nickel | 6.9E+00 | µg/L | 1.8E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.1E-07 | mg/kg-day | 8.0E-04 | mg/kg-day | 2.6E-04 |
| | | | | Selenium | 2.3E+00 | µg/L | 2.9E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.3E-07 | mg/kg-day | 5.0E-03 | mg/kg-day | 6.7E-05 |
| | | | | Silver | 1.0E+00 | µg/L | 1.3E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.5E-07 | mg/kg-day | 2.0E-04 | mg/kg-day | 7.7E-04 |
| | | | | Vanadium | 3.4E+00 | µg/L | 4.3E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 5.1E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 4.7E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 5.5E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 2E-07 | | | | | 9E-02 |
| | | Exposure Point Total | | | | | | | | | 8E-06 | | | | | 1E+00 |
| | Exposure Medium Total | | | | | | | | | | 8E-06 | | | | | 1E+00 |

**Table 7.3.CT**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Air | Shower Air | Inhalation | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 2.7E+00 | $\mu g/m^3$ | 4.0E-03 | $\mu g/m^3$ | 1.6E-06 | $(\mu g/m^3)^{-1}$ | 6.3E-09 | 4.6E-02 | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Benzene | 4.7E+00 | $\mu g/m^3$ | 7.0E-03 | $\mu g/m^3$ | 7.8E-06 | $(\mu g/m^3)^{-1}$ | 5.4E-08 | 8.1E-02 | $\mu g/m^3$ | 3.0E-02 | $mg/m^3$ | 2.7E-03 |
| | | | | Methyl tert butyl ether | 3.6E+00 | $\mu g/m^3$ | 5.2E-03 | $\mu g/m^3$ | 2.6E-07 | $(\mu g/m^3)^{-1}$ | 1.4E-09 | 6.1E-02 | $\mu g/m^3$ | 3.0E+00 | $mg/m^3$ | 2.0E-05 |
| | | | | Toluene | 1.7E+01 | $\mu g/m^3$ | 2.5E-02 | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | 2.9E-01 | $\mu g/m^3$ | 5.0E+00 | $mg/m^3$ | 5.8E-05 |
| | | | | Trichloroethene | 8.3E-01 | $\mu g/m^3$ | 5.1E-03 | $\mu g/m^3$ | 4.1E-06 | $(\mu g/m^3)^{-1}$ | 2.1E-08 | 1.4E-02 | $\mu g/m^3$ | 2.0E-03 | $mg/m^3$ | 7.1E-03 |
| | | | | Xylenes | 8.9E+00 | $\mu g/m^3$ | 1.3E-02 | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | 1.5E-01 | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.4E-06 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Naphthalene | 8.2E-01 | $\mu g/m^3$ | 1.2E-03 | $\mu g/m^3$ | 3.4E-05 | $(\mu g/m^3)^{-1}$ | 4.1E-08 | 1.4E-02 | $\mu g/m^3$ | 3.0E-03 | $mg/m^3$ | 4.7E-03 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-03 | $mg/m^3$ | NA |
| | | | | Arsenic | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 4.3E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.5E-05 | $mg/m^3$ | NA |
| | | | | Barium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-04 | $mg/m^3$ | NA |
| | | | | Cadmium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.8E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 1.0E-05 | $mg/m^3$ | NA |
| | | | | Chromium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 1.2E-02 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 8.0E-06 | $mg/m^3$ | NA |
| | | | | Cobalt | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 9.0E-03 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 6.0E-06 | $mg/m^3$ | NA |
| | | | | Copper | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Iron | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Lead | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Manganese | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 5.0E-05 | $mg/m^3$ | NA |
| | | | | Nickel | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | 2.6E-04 | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 9.0E-05 | $mg/m^3$ | NA |
| | | | | Selenium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | 2.0E-02 | $mg/m^3$ | NA |
| | | | | Silver | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Vanadium | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | | Zinc | NA | $\mu g/m^3$ | NA | $\mu g/m^3$ | NA | $(\mu g/m^3)^{-1}$ | NA | NA | $\mu g/m^3$ | NA | $mg/m^3$ | NA |
| | | | Exp. Route Total | | | | | | | | 1E-07 | | | | | 1E-02 |
| | | Exposure Point Total | | | | | | | | | 1E-07 | | | | | 1E-02 |
| | Exposure Medium Total | | | | | | | | | | 1E-07 | | | | | 1E-02 |
| Medium Total | | | | | | | | | | | 8E-06 | | | | | 1E+00 |
| Receptor Total | | | | | | | Total of Receptor Risks Across All Media | | | | 8E-06 | Total of Receptor Hazards Across All Media | | | | 1E+00 |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
CSF = cancer slope factor
EPC = exposure point concentration
mg/kg/day = milligrams per kilogram per day
$(mg/kg/day)^{-1}$ = per milligram per kilogram per day
$mg/m^3$ = milligrams per cubic meter
NA = not available or not applicable
RfC = reference concentration
RfD = reference dose
µg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter
$(\mu g/m^3)^{-1}$ = per microgram per cubic meter

**Table 7.3.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Ingestion | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 4.6E-06 | mg/kg-day | 5.7E-03 | (mg/kg-day)$^{-1}$ | 2.6E-08 | 5.3E-05 | mg/kg-day | 2.0E-01 | mg/kg-day | 2.7E-04 |
| | | | | Benzene | 1.5E+00 | µg/L | 8.2E-06 | mg/kg-day | 5.5E-02 | (mg/kg-day)$^{-1}$ | 4.5E-07 | 9.6E-05 | mg/kg-day | 4.0E-03 | mg/kg-day | 2.4E-02 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 7.2E-06 | mg/kg-day | 1.8E-03 | (mg/kg-day)$^{-1}$ | 1.3E-08 | 8.4E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 3.1E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.7E-04 | mg/kg-day | 8.0E-02 | mg/kg-day | 4.6E-03 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 6.0E-06 | mg/kg-day | 4.6E-02 | (mg/kg-day)$^{-1}$ | 2.8E-07 | 1.7E-05 | mg/kg-day | 5.0E-04 | mg/kg-day | 3.4E-02 |
| | | | | Xylenes | 2.9E+00 | µg/L | 1.6E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.8E-04 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 8.6E-06 | mg/kg-day | 1.4E-02 | (mg/kg-day)$^{-1}$ | 1.2E-07 | 1.0E-04 | mg/kg-day | 2.0E-02 | mg/kg-day | 5.0E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 1.7E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.0E-05 | mg/kg-day | 2.0E-02 | mg/kg-day | 1.0E-03 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 7.8E-03 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 9.1E-02 | mg/kg-day | 1.0E+00 | mg/kg-day | 9.1E-02 |
| | | | | Arsenic | 2.8E+00 | µg/L | 1.5E-05 | mg/kg-day | 1.5E+00 | (mg/kg-day)$^{-1}$ | 2.3E-05 | 1.8E-04 | mg/kg-day | 3.0E-04 | mg/kg-day | 5.9E-01 |
| | | | | Barium | 9.4E+01 | µg/L | 5.1E-04 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.0E-03 | mg/kg-day | 2.0E-01 | mg/kg-day | 3.0E-02 |
| | | | | Cadmium | 4.2E-01 | µg/L | 2.3E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.7E-05 | mg/kg-day | 5.0E-04 | mg/kg-day | 5.3E-02 |
| | | | | Chromium | 4.3E+00 | µg/L | 9.9E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.8E-04 | mg/kg-day | 3.0E-03 | mg/kg-day | 9.2E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 1.4E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.7E-04 | mg/kg-day | 3.0E-04 | mg/kg-day | 5.5E-01 |
| | | | | Copper | 7.1E+00 | µg/L | 3.9E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.5E-04 | mg/kg-day | 4.0E-02 | mg/kg-day | 1.1E-02 |
| | | | | Iron | 1.2E+04 | µg/L | 6.8E-02 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 7.9E-01 | mg/kg-day | 7.0E-01 | mg/kg-day | 1.1E+00 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 1.0E-02 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.2E-01 | mg/kg-day | 1.4E-01 | mg/kg-day | 8.6E-01 |
| | | | | Nickel | 6.9E+00 | µg/L | 3.8E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.4E-04 | mg/kg-day | 2.0E-02 | mg/kg-day | 2.2E-02 |
| | | | | Selenium | 2.3E+00 | µg/L | 1.2E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.4E-04 | mg/kg-day | 5.0E-03 | mg/kg-day | 2.9E-02 |
| | | | | Silver | 1.0E+00 | µg/L | 5.7E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 6.6E-05 | mg/kg-day | 5.0E-03 | mg/kg-day | 1.3E-02 |
| | | | | Vanadium | 3.4E+00 | µg/L | 1.9E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.2E-04 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 3.4E-03 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.0E-02 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 2E-05 | | | | | 4E+00 |

**Table 7.3.RME**
**Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| |
|---|
| Scenario Timeframe: Future |
| Receptor Population: Hypothetical Future Resident |
| Receptor Age: Young Child |

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Groundwater | Tap Water | Dermal | | | | | | | | | | | | | |
| | | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 8.3E-01 | µg/L | 2.8E-07 | mg/kg-day | 5.7E-03 | (mg/kg-day)$^{-1}$ | 1.6E-09 | 3.2E-06 | mg/kg-day | 2.0E-01 | mg/kg-day | 1.6E-05 |
| | | | | Benzene | 1.5E+00 | µg/L | 9.6E-07 | mg/kg-day | 5.5E-02 | (mg/kg-day)$^{-1}$ | 5.3E-08 | 1.1E-05 | mg/kg-day | 4.0E-03 | mg/kg-day | 2.8E-03 |
| | | | | Methyl tert butyl ether | 1.3E+00 | µg/L | 1.3E-07 | mg/kg-day | 1.8E-03 | (mg/kg-day)$^{-1}$ | 2.3E-10 | 1.5E-06 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Toluene | 5.7E+00 | µg/L | 8.4E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 9.8E-05 | mg/kg-day | 8.0E-02 | mg/kg-day | 1.2E-03 |
| | | | | Trichloroethene | 2.6E-01 | µg/L | 7.7E-07 | mg/kg-day | 4.6E-02 | (mg/kg-day)$^{-1}$ | 3.6E-08 | 2.2E-06 | mg/kg-day | 5.0E-04 | mg/kg-day | 4.3E-03 |
| | | | | Xylenes | 2.9E+00 | µg/L | 7.4E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 8.7E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | 1.6E+00 | µg/L | 1.0E-05 | mg/kg-day | 1.4E-02 | (mg/kg-day)$^{-1}$ | 1.4E-07 | 1.2E-04 | mg/kg-day | 2.0E-02 | mg/kg-day | 5.9E-03 |
| | | | | Naphthalene | 3.1E-01 | µg/L | 1.7E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.0E-06 | mg/kg-day | 2.0E-02 | mg/kg-day | 1.0E-04 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | 1.4E+03 | µg/L | 2.9E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.4E-04 | mg/kg-day | 1.0E+00 | mg/kg-day | 3.4E-04 |
| | | | | Arsenic | 2.8E+00 | µg/L | 5.7E-08 | mg/kg-day | 1.5E+00 | (mg/kg-day)$^{-1}$ | 8.5E-08 | 6.6E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 2.2E-03 |
| | | | | Barium | 9.4E+01 | µg/L | 1.9E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.2E-05 | mg/kg-day | 1.4E-02 | mg/kg-day | 1.6E-03 |
| | | | | Cadmium | 4.2E-01 | µg/L | 8.5E-09 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.0E-07 | mg/kg-day | 2.5E-05 | mg/kg-day | 4.0E-03 |
| | | | | Chromium | 4.3E+00 | µg/L | 7.4E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.1E-06 | mg/kg-day | 7.5E-05 | mg/kg-day | 2.8E-02 |
| | | | | Cobalt | 2.6E+00 | µg/L | 2.1E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.5E-07 | mg/kg-day | 3.0E-04 | mg/kg-day | 8.3E-04 |
| | | | | Copper | 7.1E+00 | µg/L | 1.5E-07 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 1.7E-06 | mg/kg-day | 4.0E-02 | mg/kg-day | 4.3E-05 |
| | | | | Iron | 1.2E+04 | µg/L | 2.5E-04 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.0E-03 | mg/kg-day | 7.0E-01 | mg/kg-day | 4.2E-03 |
| | | | | Lead | NA | µg/L | NA | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | NA | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Manganese | 1.9E+03 | µg/L | 3.9E-05 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 4.5E-04 | mg/kg-day | 5.6E-03 | mg/kg-day | 8.0E-02 |
| | | | | Nickel | 6.9E+00 | µg/L | 2.8E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 3.3E-07 | mg/kg-day | 8.0E-04 | mg/kg-day | 4.1E-04 |
| | | | | Selenium | 2.3E+00 | µg/L | 4.6E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 5.4E-07 | mg/kg-day | 5.0E-03 | mg/kg-day | 1.1E-04 |
| | | | | Silver | 1.0E+00 | µg/L | 2.1E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 2.5E-07 | mg/kg-day | 2.0E-04 | mg/kg-day | 1.2E-03 |
| | | | | Vanadium | 3.4E+00 | µg/L | 7.0E-08 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 8.2E-07 | mg/kg-day | NA | mg/kg-day | NA |
| | | | | Zinc | 6.2E+02 | µg/L | 7.6E-06 | mg/kg-day | NA | (mg/kg-day)$^{-1}$ | NA | 8.9E-05 | mg/kg-day | NA | mg/kg-day | NA |
| | | | Exp. Route Total | | | | | | | | 3E-07 | | | | | 1E-01 |
| | | Exposure Point Total | | | | | | | | | 2E-05 | | | | | 4E+00 |
| | Exposure Medium Total | | | | | | | | | | 2E-05 | | | | | 4E+00 |

Table 7.3.RME
Calculation of Chemical Cancer Risks and Non-Cancer Hazards - Hypothetical Future Resident - Young Child
Reasonable Maximum Exposure

Site-Related Groundwater BHHRA
Ringwood Mines/Landfill Superfund Site
Ringwood, New Jersey

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Point | Route | Chemical of Potential Concern | EPC | | Cancer Risk Calculations | | | | | Non-Cancer Hazard Calculations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Value | Units | Intake/Exposure Concentration | | CSF/Unit Risk | | Risk | Intake/Exposure Concentration | | RfD/RfC | | Hazard Quotient |
| | | | | | | | Value | Units | Value | Units | | Value | Units | Value | Units | |
| Groundwater | Air | Shower Air | Inhalation | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | |
| | | | | 1,1-Dichloroethane | 6.6E+00 | μg/m$^3$ | 1.6E-02 | μg/m$^3$ | 1.6E-06 | (μg/m$^3$)$^{-1}$ | 2.6E-08 | 1.9E-01 | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Benzene | 1.2E+01 | μg/m$^3$ | 2.9E-02 | μg/m$^3$ | 7.8E-06 | (μg/m$^3$)$^{-1}$ | 2.2E-07 | 3.4E-01 | μg/m$^3$ | 3.0E-02 | mg/m$^3$ | 1.1E-02 |
| | | | | Methyl tert butyl ether | 8.8E+00 | μg/m$^3$ | 2.2E-02 | μg/m$^3$ | 2.6E-07 | (μg/m$^3$)$^{-1}$ | 5.6E-09 | 2.5E-01 | μg/m$^3$ | 3.0E+00 | mg/m$^3$ | 8.4E-05 |
| | | | | Toluene | 4.2E+01 | μg/m$^3$ | 1.0E-01 | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | 1.2E+00 | μg/m$^3$ | 5.0E+00 | mg/m$^3$ | 2.4E-04 |
| | | | | Trichloroethene | 2.0E+00 | μg/m$^3$ | 2.1E-02 | μg/m$^3$ | 4.1E-06 | (μg/m$^3$)$^{-1}$ | 8.6E-08 | 5.9E-02 | μg/m$^3$ | 2.0E-03 | mg/m$^3$ | 2.9E-02 |
| | | | | Xylenes | 2.2E+01 | μg/m$^3$ | 5.4E-02 | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | 6.3E-01 | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| | | | | bis(2-Ethylhexyl)phthalate | NA | μg/m$^3$ | NA | μg/m$^3$ | 2.4E-06 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Naphthalene | 2.0E+00 | μg/m$^3$ | 5.0E-03 | μg/m$^3$ | 3.4E-05 | (μg/m$^3$)$^{-1}$ | 1.7E-07 | 5.8E-02 | μg/m$^3$ | 3.0E-03 | mg/m$^3$ | 1.9E-02 |
| | | | | **Metals - Total** | | | | | | | | | | | | |
| | | | | Aluminum | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 5.0E-03 | mg/m$^3$ | NA |
| | | | | Arsenic | NA | μg/m$^3$ | NA | μg/m$^3$ | 4.3E-03 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 1.5E-05 | mg/m$^3$ | NA |
| | | | | Barium | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 5.0E-04 | mg/m$^3$ | NA |
| | | | | Cadmium | NA | μg/m$^3$ | NA | μg/m$^3$ | 1.8E-03 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 1.0E-05 | mg/m$^3$ | NA |
| | | | | Chromium | NA | μg/m$^3$ | NA | μg/m$^3$ | 1.2E-02 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 8.0E-06 | mg/m$^3$ | NA |
| | | | | Cobalt | NA | μg/m$^3$ | NA | μg/m$^3$ | 9.0E-03 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 6.0E-06 | mg/m$^3$ | NA |
| | | | | Copper | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Iron | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Lead | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Manganese | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 5.0E-05 | mg/m$^3$ | NA |
| | | | | Nickel | NA | μg/m$^3$ | NA | μg/m$^3$ | 2.6E-04 | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 9.0E-05 | mg/m$^3$ | NA |
| | | | | Selenium | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | 2.0E-02 | mg/m$^3$ | NA |
| | | | | Silver | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Vanadium | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | | Zinc | NA | μg/m$^3$ | NA | μg/m$^3$ | NA | (μg/m$^3$)$^{-1}$ | NA | NA | μg/m$^3$ | NA | mg/m$^3$ | NA |
| | | | Exp. Route Total | | | | | | | | 5E-07 | | | | | 6E-02 |
| | | Exposure Point Total | | | | | | | | | 5E-07 | | | | | 6E-02 |
| | Exposure Medium Total | | | | | | | | | | 5E-07 | | | | | 6E-02 |
| Medium Total | | | | | | | | | | | 2E-05 | | | | | 4E+00 |
| Receptor Total | | | | | | | Total of Receptor Risks Across All Media | | | | 2E-05 | Total of Receptor Hazards Across All Media | | | | 4E+00 |

**Acronyms and Abbreviations:**
BHHRA = Baseline Human Health Risk Assessment
CSF = cancer slope factor
EPC = exposure point concentration
mg/kg/day = milligrams per kilogram per day
(mg/kg/day)$^{-1}$ = per milligram per kilogram per day
mg/m$^3$ = milligrams per cubic meter
NA = not available or not applicable
RfC = reference concentration
RfD = reference dose
μg/L = micrograms per liter
μg/m$^3$ = micrograms per cubic meter
(μg/m$^3$)$^{-1}$ = per microgram per cubic meter

**Table 9.1.CT**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Adult**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Groundwater | Tap Water | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | NA | -- | NA | NA | kidney | NA | -- | NA | NA |
| | | | Benzene | NA | -- | NA | NA | immune system | NA | -- | NA | NA |
| | | | Methyl tert butyl ether | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Toluene | NA | -- | NA | NA | kidney | NA | -- | NA | NA |
| | | | Trichloroethene | NA | -- | NA | NA | heart, development, immune system | NA | -- | NA | NA |
| | | | Xylenes | NA | -- | NA | NA | body weight, mortality | NA | -- | NA | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | NA | -- | NA | NA | liver | NA | -- | NA | NA |
| | | | Naphthalene | NA | -- | NA | NA | body weight | NA | -- | NA | NA |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | NA | -- | NA | NA | developmental, neurobehavioral | NA | -- | NA | NA |
| | | | Arsenic | NA | -- | NA | NA | skin, vascular | NA | -- | NA | NA |
| | | | Barium | NA | -- | NA | NA | kidney | NA | -- | NA | NA |
| | | | Cadmium | NA | -- | NA | NA | kidney | NA | -- | NA | NA |
| | | | Chromium | NA | -- | NA | NA | NR | NA | -- | NA | NA |
| | | | Cobalt | NA | -- | NA | NA | thyroid | NA | -- | NA | NA |
| | | | Copper | NA | -- | NA | NA | GI | NA | -- | NA | NA |
| | | | Iron | NA | -- | NA | NA | GI | NA | -- | NA | NA |
| | | | Lead | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Manganese | NA | -- | NA | NA | CNS | NA | -- | NA | NA |
| | | | Nickel | NA | -- | NA | NA | body weight | NA | -- | NA | NA |
| | | | Selenium | NA | -- | NA | NA | hair, nails, skin, blood, CNS | NA | -- | NA | NA |
| | | | Silver | NA | -- | NA | NA | skin | NA | -- | NA | NA |
| | | | Vanadium | NA | -- | NA | NA | hair | NA | -- | NA | NA |
| | | | Zinc | NA | -- | NA | NA | blood | NA | -- | NA | NA |
| | | | Chemical Total | 0.E+00 | -- | 0.E+00 | 0.E+00 | | 0E+00 | -- | 0.E+00 | 0.E+00 |
| | | Exposure Point Total | | | | | 0.E+00 | | | | | 0.E+00 |
| | Exposure Medium Total | | | | | | 0.E+00 | | | | | 0.E+00 |

**Table 9.1.CT**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Adult**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Air | Shower Air | | | | | | | | | | |
| | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Benzene | -- | NA | -- | NA | immune system | -- | NA | -- | NA |
| | | | Methyl tert butyl ether | -- | NA | -- | NA | liver, kidney | -- | NA | -- | NA |
| | | | Toluene | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Trichloroethene | -- | NA | -- | NA | heart, development, immune system | -- | NA | -- | NA |
| | | | Xylenes | -- | NA | -- | NA | CNS | -- | NA | -- | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Naphthalene | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Arsenic | -- | NA | -- | NA | developmental, neurobehavioral | -- | NA | -- | NA |
| | | | Barium | -- | NA | -- | NA | fetus | -- | NA | -- | NA |
| | | | Cadmium | -- | NA | -- | NA | kidney, respiratory system | -- | NA | -- | NA |
| | | | Chromium | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Iron | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Lead | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Manganese | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Nickel | -- | NA | -- | NA | respiratory system | -- | NA | -- | NA |
| | | | Selenium | -- | NA | -- | NA | hair, nails, skin, blood, CNS | -- | NA | -- | NA |
| | | | Silver | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Vanadium | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Zinc | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Chemical Total | -- | 0.E+00 | -- | 0.E+00 | | -- | 0.E+00 | -- | 0.E+00 |
| | | Exposure Point Total | | | | | 0.E+00 | | | | | 0.E+00 |
| | Exposure Medium Total | | | | | | 0.E+00 | | | | | 0.E+00 |
| Medium Total | | | | | | | 0.E+00 | | | | | 0.E+00 |
| Receptor Total | | | | | | Receptor Risk Total | 0.E+00 | | | | Receptor HI Total | 0.E+00 |

**Footnotes:**
(1) The exposure duration (ED) for the hypothetical future adult resident under a central tendency (CT) scenario is set to 0 years (see Table 4.1.CT); therefore, risks and hazards are not calculated for this receptor.

| | |
|---|---|
| Total Circulatory System (Blood, Heart, Vascular) HI Across All Media = | NA |
| Total Reproductive/Developmental (Development, Developmental, Fetus) HI Across All Media = | NA |
| Total GI HI Across All Media = | NA |
| Total Immune System HI Across All Media = | NA |
| Total Kidney HI Across All Media = | NA |
| Total Liver HI Across All Media = | NA |
| Total Nervous System (CNS, Neurobehavioral, Neurological) HI Across All Media = | NA |
| Total "Not Reported" HI Across All Media = | NA |
| Total Respiratory System (Lung, Nasal, Respiratory System) HI Across All Media = | NA |
| Total Skin (Hair, Nails, Skin) HI Across All Media = | NA |
| Total Thyroid HI Across All Media = | NA |
| Total Whole Body (Body Weight, Mortality) HI Across All Media = | NA |

**Acronyms and Abbreviations:**
-- = not an exposure route for this media
BHHRA = Baseline Human Health Risk Assessment
CNS = central nervous system
COPC = constituent of potential concern
GI = gastrointestinal tract
NA = not available or not applicable
NR = none reported

**Table 9.1.RME**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Adult**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Groundwater | Tap Water | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | 7.E-08 | -- | 6.E-09 | 7.E-08 | kidney | 1.E-04 | -- | 1.E-05 | 1.E-04 |
| | | | Benzene | 1.E-06 | -- | 2.E-07 | 1.E-06 | immune system | 1.E-02 | -- | 2.E-03 | 1.E-02 |
| | | | Methyl tert butyl ether | 3.E-08 | -- | 9.E-10 | 3.E-08 | NA | NA | -- | NA | NA |
| | | | Toluene | NA | -- | NA | NA | kidney | 2.E-03 | -- | 8.E-04 | 3.E-03 |
| | | | Trichloroethene | 2.E-07 | -- | 3.E-08 | 2.E-07 | heart, development, immune system | 1.E-02 | -- | 3.E-03 | 2.E-02 |
| | | | Xylenes | NA | -- | NA | NA | body weight, mortality | NA | -- | NA | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | 3.E-07 | -- | 6.E-07 | 9.E-07 | liver | 2.E-03 | -- | 4.E-03 | 6.E-03 |
| | | | Naphthalene | NA | -- | NA | NA | body weight | 4.E-04 | -- | 6.E-05 | 5.E-04 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | NA | -- | NA | NA | developmental, neurobehavioral | 4.E-02 | -- | 3.E-04 | 4.E-02 |
| | | | Arsenic | 6.E-05 | -- | 4.E-07 | 6.E-05 | skin, vascular | 3.E-01 | -- | 2.E-03 | 3.E-01 |
| | | | Barium | NA | -- | NA | NA | kidney | 1.E-02 | -- | 1.E-03 | 1.E-02 |
| | | | Cadmium | NA | -- | NA | NA | kidney | 2.E-02 | -- | 3.E-03 | 3.E-02 |
| | | | Chromium | NA | -- | NA | NA | NR | 4.E-02 | -- | 2.E-02 | 6.E-02 |
| | | | Cobalt | NA | -- | NA | NA | thyroid | 2.E-01 | -- | 6.E-04 | 2.E-01 |
| | | | Copper | NA | -- | NA | NA | GI | 5.E-03 | -- | 3.E-05 | 5.E-03 |
| | | | Iron | NA | -- | NA | NA | GI | 5.E-01 | -- | 3.E-03 | 5.E-01 |
| | | | Lead | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Manganese | NA | -- | NA | NA | CNS | 4.E-01 | -- | 6.E-02 | 4.E-01 |
| | | | Nickel | NA | -- | NA | NA | body weight | 9.E-03 | -- | 3.E-04 | 1.E-02 |
| | | | Selenium | NA | -- | NA | NA | hair, nails, skin, blood, CNS | 1.E-02 | -- | 8.E-05 | 1.E-02 |
| | | | Silver | NA | -- | NA | NA | skin | 6.E-03 | -- | 9.E-04 | 7.E-03 |
| | | | Vanadium | NA | -- | NA | NA | hair | NA | -- | NA | NA |
| | | | Zinc | NA | -- | NA | NA | blood | NA | -- | NA | NA |
| | | | Chemical Total | 6.E-05 | -- | 1.E-06 | 6.E-05 | | 2E+00 | -- | 1.E-01 | 2.E+00 |
| | | Exposure Point Total | | | | | 6.E-05 | | | | | 2.E+00 |
| | Exposure Medium Total | | | | | | 6.E-05 | | | | | 2.E+00 |

**Table 9.1.RME**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Adult**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Air | Shower Air | | | | | | | | | | |
| | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | -- | 3.E-07 | -- | 3.E-07 | NA | -- | NA | -- | NA |
| | | | Benzene | -- | 2.E-06 | -- | 2.E-06 | immune system | -- | 2.E-02 | -- | 2.E-02 |
| | | | Methyl tert butyl ether | -- | 6.E-08 | -- | 6.E-08 | liver, kidney | -- | 1.E-04 | -- | 1.E-04 |
| | | | Toluene | -- | NA | -- | NA | neurological | -- | 4.E-04 | -- | 4.E-04 |
| | | | Trichloroethene | -- | 2.E-07 | -- | 2.E-07 | heart, development, immune system | -- | 5.E-02 | -- | 5.E-02 |
| | | | Xylenes | -- | NA | -- | NA | CNS | -- | NA | -- | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Naphthalene | -- | 2.E-06 | -- | 2.E-06 | nasal | -- | 3.E-02 | -- | 3.E-02 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Arsenic | -- | NA | -- | NA | developmental, neurobehavioral | -- | NA | -- | NA |
| | | | Barium | -- | NA | -- | NA | fetus | -- | NA | -- | NA |
| | | | Cadmium | -- | NA | -- | NA | kidney, respiratory system | -- | NA | -- | NA |
| | | | Chromium | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Iron | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Lead | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Manganese | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Nickel | -- | NA | -- | NA | respiratory system | -- | NA | -- | NA |
| | | | Selenium | -- | NA | -- | NA | hair, nails, skin, blood, CNS | -- | NA | -- | NA |
| | | | Silver | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Vanadium | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Zinc | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Chemical Total | -- | 4.E-06 | -- | 4.E-06 | | -- | 1.E-01 | -- | 1.E-01 |
| | | Exposure Point Total | | | | | 4.E-06 | | | | | 1.E-01 |
| | Exposure Medium Total | | | | | | 4.E-06 | | | | | 1.E-01 |
| Medium Total | | | | | | | 7.E-05 | | | | | 2.E+00 |
| Receptor Total | | | | | | Receptor Risk Total | 7.E-05 | | | | Receptor HI Total | 2.E+00 |

**Acronyms and Abbreviations:**

-- = not an exposure route for this media
BHHRA = Baseline Human Health Risk Assessment
CNS = central nervous system
COPC = constituent of potential concern
GI = gastrointestinal tract
NA = not available or not applicable
NR = none reported

| | |
|---|---|
| Total Circulatory System (Blood, Heart, Vascular) HI Across All Media = | 0.3 |
| Total Reproductive/Developmental (Development, Developmental, Fetus) HI Across All Media = | 0.1 |
| Total GI HI Across All Media = | 0.5 |
| Total Immune System HI Across All Media = | 0.1 |
| Total Kidney HI Across All Media = | 0.04 |
| Total Liver HI Across All Media = | 0.01 |
| Total Nervous System (CNS, Neurobehavioral, Neurological) HI Across All Media = | 0.5 |
| Total "Not Reported" HI Across All Media = | 0.06 |
| Total Respiratory System (Lung, Nasal, Respiratory System) HI Across All Media = | 0.03 |
| Total Skin (Hair, Nails, Skin) HI Across All Media = | 0.3 |
| Total Thyroid HI Across All Media = | 0.2 |
| Total Whole Body (Body Weight, Mortality) HI Across All Media = | 0.010 |

**Table 9.2.CT**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Youth**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Groundwater | Tap Water | | | | | | | | | | |
| | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | 2.E-09 | -- | 4.E-10 | 2.E-09 | kidney | 4.E-05 | -- | 8.E-06 | 5.E-05 |
| | | | Benzene | 4.E-08 | -- | 1.E-08 | 5.E-08 | immune system | 4.E-03 | -- | 1.E-03 | 5.E-03 |
| | | | Methyl tert butyl ether | 1.E-09 | -- | 6.E-11 | 1.E-09 | NA | NA | -- | NA | NA |
| | | | Toluene | NA | -- | NA | NA | kidney | 7.E-04 | -- | 6.E-04 | 1.E-03 |
| | | | Trichloroethene | 2.E-08 | -- | 6.E-09 | 2.E-08 | heart, development, immune system | 5.E-03 | -- | 2.E-03 | 7.E-03 |
| | | | Xylenes | NA | -- | NA | NA | body weight, mortality | NA | -- | NA | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | 1.E-08 | -- | 3.E-08 | 4.E-08 | liver | 8.E-04 | -- | 3.E-03 | 4.E-03 |
| | | | Naphthalene | NA | -- | NA | NA | body weight | 2.E-04 | -- | 5.E-05 | 2.E-04 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | NA | -- | NA | NA | developmental, neurobehavioral | 1.E-02 | -- | 1.E-04 | 1.E-02 |
| | | | Arsenic | 2.E-06 | -- | 2.E-08 | 2.E-06 | skin, vascular | 9.E-02 | -- | 8.E-04 | 1.E-01 |
| | | | Barium | NA | -- | NA | NA | kidney | 5.E-03 | -- | 6.E-04 | 5.E-03 |
| | | | Cadmium | NA | -- | NA | NA | kidney | 9.E-03 | -- | 2.E-03 | 1.E-02 |
| | | | Chromium | NA | -- | NA | NA | NR | 1.E-02 | -- | 1.E-02 | 3.E-02 |
| | | | Cobalt | NA | -- | NA | NA | thyroid | 9.E-02 | -- | 3.E-04 | 9.E-02 |
| | | | Copper | NA | -- | NA | NA | GI | 2.E-03 | -- | 2.E-05 | 2.E-03 |
| | | | Iron | NA | -- | NA | NA | GI | 2.E-01 | -- | 2.E-03 | 2.E-01 |
| | | | Lead | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Manganese | NA | -- | NA | NA | CNS | 1.E-01 | -- | 3.E-02 | 2.E-01 |
| | | | Nickel | NA | -- | NA | NA | body weight | 4.E-03 | -- | 2.E-04 | 4.E-03 |
| | | | Selenium | NA | -- | NA | NA | hair, nails, skin, blood, CNS | 5.E-03 | -- | 4.E-05 | 5.E-03 |
| | | | Silver | NA | -- | NA | NA | skin | 2.E-03 | -- | 5.E-04 | 3.E-03 |
| | | | Vanadium | NA | -- | NA | NA | hair | NA | -- | NA | NA |
| | | | Zinc | NA | -- | NA | NA | blood | NA | -- | NA | NA |
| | | | Chemical Total | 2.E-06 | -- | 7.E-08 | 2.E-06 | | 6E-01 | -- | 5.E-02 | 6.E-01 |
| | | Exposure Point Total | | | | | 2.E-06 | | | | | 6.E-01 |
| | Exposure Medium Total | | | | | | 2.E-06 | | | | | 6.E-01 |

**Table 9.2.CT**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Youth**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Air | Shower Air | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | -- | 3.E-09 | -- | 3.E-09 | NA | -- | NA | -- | NA |
| | | | Benzene | -- | 3.E-08 | -- | 3.E-08 | immune system | -- | 3.E-03 | -- | 3.E-03 |
| | | | Methyl tert butyl ether | -- | 6.E-10 | -- | 6.E-10 | liver, kidney | -- | 2.E-05 | -- | 2.E-05 |
| | | | Toluene | -- | NA | -- | NA | neurological | -- | 6.E-05 | -- | 6.E-05 |
| | | | Trichloroethene | -- | 7.E-09 | -- | 7.E-09 | heart, development, immune system | -- | 7.E-03 | -- | 7.E-03 |
| | | | Xylenes | -- | NA | -- | NA | CNS | -- | NA | -- | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Naphthalene | -- | 2.E-08 | -- | 2.E-08 | nasal | -- | 4.E-03 | -- | 4.E-03 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Arsenic | -- | NA | -- | NA | developmental, neurobehavioral | -- | NA | -- | NA |
| | | | Barium | -- | NA | -- | NA | fetus | -- | NA | -- | NA |
| | | | Cadmium | -- | NA | -- | NA | kidney, respiratory system | -- | NA | -- | NA |
| | | | Chromium | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Iron | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Lead | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Manganese | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Nickel | -- | NA | -- | NA | respiratory system | -- | NA | -- | NA |
| | | | Selenium | -- | NA | -- | NA | hair, nails, skin, blood, CNS | -- | NA | -- | NA |
| | | | Silver | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Vanadium | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Zinc | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Chemical Total | -- | 6.E-08 | -- | 6.E-08 | | -- | 1.E-02 | -- | 1.E-02 |
| | | Exposure Point Total | | | | | 6.E-08 | | | | | 1.E-02 |
| | Exposure Medium Total | | | | | | 6.E-08 | | | | | 1.E-02 |
| Medium Total | | | | | | | 2.E-06 | | | | | 6.E-01 |
| Receptor Total | | | | | | Receptor Risk Total | 2.E-06 | | | | Receptor HI Total | 6.E-01 |

**Acronyms and Abbreviations:**

-- = not an exposure route for this media
BHHRA = Baseline Human Health Risk Assessment
CNS = central nervous system
COPC = constituent of potential concern
GI = gastrointestinal tract
NA = not available or not applicable
NR = none reported

| | |
|---|---|
| Total Circulatory System (Blood, Heart, Vascular) HI Across All Media = | 0.1 |
| Total Reproductive/Developmental (Development, Developmental, Fetus) HI Across All Media = | 0.03 |
| Total GI HI Across All Media = | 0.2 |
| Total Immune System HI Across All Media = | 0.02 |
| Total Kidney HI Across All Media = | 0.02 |
| Total Liver HI Across All Media = | 0.004 |
| Total Nervous System (CNS, Neurobehavioral, Neurological) HI Across All Media = | 0.2 |
| Total "Not Reported" HI Across All Media = | 0.03 |
| Total Respiratory System (Lung, Nasal, Respiratory System) HI Across All Media = | 0.004 |
| Total Skin (Hair, Nails, Skin) HI Across All Media = | 0.1 |
| Total Thyroid HI Across All Media = | 0.1 |
| Total Whole Body (Body Weight, Mortality) HI Across All Media = | 0.004 |

**Table 9.2.RME**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Youth**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Groundwater | Tap Water | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | 3.E-08 | -- | 2.E-09 | 3.E-08 | kidney | 2.E-04 | -- | 1.E-05 | 2.E-04 |
| | | | Benzene | 5.E-07 | -- | 6.E-08 | 6.E-07 | immune system | 2.E-02 | -- | 2.E-03 | 2.E-02 |
| | | | Methyl tert butyl ether | 1.E-08 | -- | 2.E-10 | 1.E-08 | NA | NA | -- | NA | NA |
| | | | Toluene | NA | -- | NA | NA | kidney | 3.E-03 | -- | 8.E-04 | 4.E-03 |
| | | | Trichloroethene | 2.E-07 | -- | 3.E-08 | 2.E-07 | heart, development, immune system | 2.E-02 | -- | 3.E-03 | 3.E-02 |
| | | | Xylenes | NA | -- | NA | NA | body weight, mortality | NA | -- | NA | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | 1.E-07 | -- | 2.E-07 | 3.E-07 | liver | 3.E-03 | -- | 4.E-03 | 7.E-03 |
| | | | Naphthalene | NA | -- | NA | NA | body weight | 7.E-04 | -- | 6.E-05 | 7.E-04 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | NA | -- | NA | NA | developmental, neurobehavioral | 6.E-02 | -- | 2.E-04 | 6.E-02 |
| | | | Arsenic | 3.E-05 | -- | 9.E-08 | 3.E-05 | skin, vascular | 4.E-01 | -- | 1.E-03 | 4.E-01 |
| | | | Barium | NA | -- | NA | NA | kidney | 2.E-02 | -- | 1.E-03 | 2.E-02 |
| | | | Cadmium | NA | -- | NA | NA | kidney | 4.E-02 | -- | 3.E-03 | 4.E-02 |
| | | | Chromium | NA | -- | NA | NA | NR | 6.E-02 | -- | 2.E-02 | 8.E-02 |
| | | | Cobalt | NA | -- | NA | NA | thyroid | 4.E-01 | -- | 5.E-04 | 4.E-01 |
| | | | Copper | NA | -- | NA | NA | GI | 8.E-03 | -- | 3.E-05 | 8.E-03 |
| | | | Iron | NA | -- | NA | NA | GI | 8.E-01 | -- | 3.E-03 | 8.E-01 |
| | | | Lead | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Manganese | NA | -- | NA | NA | CNS | 6.E-01 | -- | 5.E-02 | 6.E-01 |
| | | | Nickel | NA | -- | NA | NA | body weight | 1.E-02 | -- | 3.E-04 | 1.E-02 |
| | | | Selenium | NA | -- | NA | NA | hair, nails, skin, blood, CNS | 2.E-02 | -- | 7.E-05 | 2.E-02 |
| | | | Silver | NA | -- | NA | NA | skin | 9.E-03 | -- | 8.E-04 | 1.E-02 |
| | | | Vanadium | NA | -- | NA | NA | hair | NA | -- | NA | NA |
| | | | Zinc | NA | -- | NA | NA | blood | NA | -- | NA | NA |
| | | | Chemical Total | 3.E-05 | -- | 3.E-07 | 3.E-05 | | 2E+00 | -- | 9.E-02 | 2.E+00 |
| | | Exposure Point Total | | | | | 3.E-05 | | | | | 2.E+00 |
| | Exposure Medium Total | | | | | | 3.E-05 | | | | | 2.E+00 |

**Table 9.2.RME**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Youth**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Air | Shower Air | | | | | | | | | | |
| | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | -- | 5.E-08 | -- | 5.E-08 | NA | -- | NA | -- | NA |
| | | | Benzene | -- | 4.E-07 | -- | 4.E-07 | immune system | -- | 1.E-02 | -- | 1.E-02 |
| | | | Methyl tert butyl ether | -- | 1.E-08 | -- | 1.E-08 | liver, kidney | -- | 1.E-04 | -- | 1.E-04 |
| | | | Toluene | -- | NA | -- | NA | neurological | -- | 3.E-04 | -- | 3.E-04 |
| | | | Trichloroethene | -- | 1.E-07 | -- | 1.E-07 | heart, development, immune system | -- | 3.E-02 | -- | 3.E-02 |
| | | | Xylenes | -- | NA | -- | NA | CNS | -- | NA | -- | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Naphthalene | -- | 3.E-07 | -- | 3.E-07 | nasal | -- | 2.E-02 | -- | 2.E-02 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Arsenic | -- | NA | -- | NA | developmental, neurobehavioral | -- | NA | -- | NA |
| | | | Barium | -- | NA | -- | NA | fetus | -- | NA | -- | NA |
| | | | Cadmium | -- | NA | -- | NA | kidney, respiratory system | -- | NA | -- | NA |
| | | | Chromium | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | Cobalt | -- | NA | -- | NA | lung | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Iron | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Lead | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Manganese | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Nickel | -- | NA | -- | NA | respiratory system | -- | NA | -- | NA |
| | | | Selenium | -- | NA | -- | NA | hair, nails, skin, blood, CNS | -- | NA | -- | NA |
| | | | Silver | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Vanadium | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Zinc | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Chemical Total | -- | 9.E-07 | -- | 9.E-07 | | -- | 7.E-02 | -- | 7.E-02 |
| | | Exposure Point Total | | | | | 9.E-07 | | | | | 7.E-02 |
| | Exposure Medium Total | | | | | | 9.E-07 | | | | | 7.E-02 |
| Medium Total | | | | | | | 3.E-05 | | | | | 3.E+00 |
| Receptor Total | | | | | | Receptor Risk Total | 3.E-05 | | | | Receptor HI Total | 3.E+00 |

**Acronyms and Abbreviations:**
-- = not an exposure route for this media
BHHRA = Baseline Human Health Risk Assessment
CNS = central nervous system
COPC = constituent of potential concern
GI = gastrointestinal tract
NA = not available or not applicable
NR = none reported

| | |
|---|---|
| Total Circulatory System (Blood, Heart, Vascular) HI Across All Media = | 0.5 |
| Total Reproductive/Developmental (Development, Developmental, Fetus) HI Across All Media = | 0.1 |
| Total GI HI Across All Media = | 0.8 |
| Total Immune System HI Across All Media = | 0.1 |
| Total Kidney HI Across All Media = | 0.06 |
| Total Liver HI Across All Media = | 0.01 |
| Total Nervous System (CNS, Neurobehavioral, Neurological) HI Across All Media = | 0.7 |
| Total "Not Reported" HI Across All Media = | 0.08 |
| Total Respiratory System (Lung, Nasal, Respiratory System) HI Across All Media = | 0.02 |
| Total Skin (Hair, Nails, Skin) HI Across All Media = | 0.4 |
| Total Thyroid HI Across All Media = | 0.4 |
| Total Whole Body (Body Weight, Mortality) HI Across All Media = | 0.02 |

**Table 9.3.CT**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Groundwater | Tap Water | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | 9.E-09 | -- | 1.E-09 | 1.E-08 | kidney | 9.E-05 | -- | 1.E-05 | 1.E-04 |
| | | | Benzene | 1.E-07 | -- | 4.E-08 | 2.E-07 | immune system | 8.E-03 | -- | 2.E-03 | 1.E-02 |
| | | | Methyl tert butyl ether | 4.E-09 | -- | 2.E-10 | 4.E-09 | NA | NA | -- | NA | NA |
| | | | Toluene | NA | -- | NA | NA | kidney | 2.E-03 | -- | 1.E-03 | 2.E-03 |
| | | | Trichloroethene | 9.E-08 | -- | 3.E-08 | 1.E-07 | heart, development, immune system | 1.E-02 | -- | 3.E-03 | 1.E-02 |
| | | | Xylenes | NA | -- | NA | NA | body weight, mortality | NA | -- | NA | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | 4.E-08 | -- | 1.E-07 | 2.E-07 | liver | 2.E-03 | -- | 5.E-03 | 6.E-03 |
| | | | Naphthalene | NA | -- | NA | NA | body weight | 3.E-04 | -- | 8.E-05 | 4.E-04 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | NA | -- | NA | NA | developmental, neurobehavioral | 3.E-02 | -- | 2.E-04 | 3.E-02 |
| | | | Arsenic | 8.E-06 | -- | 5.E-08 | 8.E-06 | skin, vascular | 2.E-01 | -- | 1.E-03 | 2.E-01 |
| | | | Barium | NA | -- | NA | NA | kidney | 1.E-02 | -- | 1.E-03 | 1.E-02 |
| | | | Cadmium | NA | -- | NA | NA | kidney | 2.E-02 | -- | 2.E-03 | 2.E-02 |
| | | | Chromium | NA | -- | NA | NA | NR | 3.E-02 | -- | 2.E-02 | 5.E-02 |
| | | | Cobalt | NA | -- | NA | NA | thyroid | 2.E-01 | -- | 5.E-04 | 2.E-01 |
| | | | Copper | NA | -- | NA | NA | GI | 4.E-03 | -- | 3.E-05 | 4.E-03 |
| | | | Iron | NA | -- | NA | NA | GI | 4.E-01 | -- | 3.E-03 | 4.E-01 |
| | | | Lead | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Manganese | NA | -- | NA | NA | CNS | 3.E-01 | -- | 5.E-02 | 3.E-01 |
| | | | Nickel | NA | -- | NA | NA | body weight | 7.E-03 | -- | 3.E-04 | 8.E-03 |
| | | | Selenium | NA | -- | NA | NA | hair, nails, skin, blood, CNS | 9.E-03 | -- | 7.E-05 | 1.E-02 |
| | | | Silver | NA | -- | NA | NA | skin | 4.E-03 | -- | 8.E-04 | 5.E-03 |
| | | | Vanadium | NA | -- | NA | NA | hair | NA | -- | NA | NA |
| | | | Zinc | NA | -- | NA | NA | blood | NA | -- | NA | NA |
| | | | Chemical Total | 8.E-06 | -- | 2.E-07 | 8.E-06 | | 1E+00 | -- | 9.E-02 | 1.E+00 |
| | | Exposure Point Total | | | | | 8.E-06 | | | | | 1.E+00 |
| | Exposure Medium Total | | | | | | 8.E-06 | | | | | 1.E+00 |

**Table 9.3.CT**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Air | Shower Air | | | | | | | | | | |
| | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | -- | 6.E-09 | -- | 6.E-09 | NA | -- | NA | -- | NA |
| | | | Benzene | -- | 5.E-08 | -- | 5.E-08 | immune system | -- | 3.E-03 | -- | 3.E-03 |
| | | | Methyl tert butyl ether | -- | 1.E-09 | -- | 1.E-09 | liver, kidney | -- | 2.E-05 | -- | 2.E-05 |
| | | | Toluene | -- | NA | -- | NA | neurological | -- | 6.E-05 | -- | 6.E-05 |
| | | | Trichloroethene | -- | 2.E-08 | -- | 2.E-08 | heart, development, immune system | -- | 7.E-03 | -- | 7.E-03 |
| | | | Xylenes | -- | NA | -- | NA | CNS | -- | NA | -- | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Naphthalene | -- | 4.E-08 | -- | 4.E-08 | nasal | -- | 5.E-03 | -- | 5.E-03 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Arsenic | -- | NA | -- | NA | developmental, neurobehavioral | -- | NA | -- | NA |
| | | | Barium | -- | NA | -- | NA | fetus | -- | NA | -- | NA |
| | | | Cadmium | -- | NA | -- | NA | kidney, respiratory system | -- | NA | -- | NA |
| | | | Chromium | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | Cobalt | -- | NA | -- | NA | lung | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Iron | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Lead | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Manganese | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Nickel | -- | NA | -- | NA | respiratory system | -- | NA | -- | NA |
| | | | Selenium | -- | NA | -- | NA | hair, nails, skin, blood, CNS | -- | NA | -- | NA |
| | | | Silver | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Vanadium | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Zinc | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Chemical Total | -- | 1.E-07 | -- | 1.E-07 | | -- | 1.E-02 | -- | 1.E-02 |
| | | Exposure Point Total | | | | | 1.E-07 | | | | | 1.E-02 |
| | Exposure Medium Total | | | | | | 1.E-07 | | | | | 1.E-02 |
| Medium Total | | | | | | | 8.E-06 | | | | | 1.E+00 |
| Receptor Total | | | | | Receptor Risk Total | | 8.E-06 | | | Receptor HI Total | | 1.E+00 |

**Acronyms and Abbreviations:**
-- = not an exposure route for this media
BHHRA = Baseline Human Health Risk Assessment
CNS = central nervous system
COPC = constituent of potential concern
GI = gastrointestinal tract
NA = not available or not applicable
NR = none reported

| | |
|---|---|
| Total Circulatory System (Blood, Heart, Vascular) HI Across All Media = | 0.2 |
| Total Reproductive/Developmental (Development, Developmental, Fetus) HI Across All Media = | 0.05 |
| Total GI HI Across All Media = | 0.4 |
| Total Immune System HI Across All Media = | 0.03 |
| Total Kidney HI Across All Media = | 0.03 |
| Total Liver HI Across All Media = | 0.01 |
| Total Nervous System (CNS, Neurobehavioral, Neurological) HI Across All Media = | 0.4 |
| Total "Not Reported" HI Across All Media = | 0.05 |
| Total Respiratory System (Lung, Nasal, Respiratory System) HI Across All Media = | 0.005 |
| Total Skin (Hair, Nails, Skin) HI Across All Media = | 0.2 |
| Total Thyroid HI Across All Media = | 0.2 |
| Total Whole Body (Body Weight, Mortality) HI Across All Media = | 0.008 |

**Table 9.3.RME**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Groundwater | Tap Water | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | 3.E-08 | -- | 2.E-09 | 3.E-08 | kidney | 3.E-04 | -- | 2.E-05 | 3.E-04 |
| | | | Benzene | 5.E-07 | -- | 5.E-08 | 5.E-07 | immune system | 2.E-02 | -- | 3.E-03 | 3.E-02 |
| | | | Methyl tert butyl ether | 1.E-08 | -- | 2.E-10 | 1.E-08 | NA | NA | -- | NA | NA |
| | | | Toluene | NA | -- | NA | NA | kidney | 5.E-03 | -- | 1.E-03 | 6.E-03 |
| | | | Trichloroethene | 3.E-07 | -- | 4.E-08 | 3.E-07 | heart, development, immune system | 3.E-02 | -- | 4.E-03 | 4.E-02 |
| | | | Xylenes | NA | -- | NA | NA | body weight, mortality | NA | -- | NA | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | 1.E-07 | -- | 1.E-07 | 3.E-07 | liver | 5.E-03 | -- | 6.E-03 | 1.E-02 |
| | | | Naphthalene | NA | -- | NA | NA | body weight | 1.E-03 | -- | 1.E-04 | 1.E-03 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | NA | -- | NA | NA | developmental, neurobehavioral | 9.E-02 | -- | 3.E-04 | 9.E-02 |
| | | | Arsenic | 2.E-05 | -- | 9.E-08 | 2.E-05 | skin, vascular | 6.E-01 | -- | 2.E-03 | 6.E-01 |
| | | | Barium | NA | -- | NA | NA | kidney | 3.E-02 | -- | 2.E-03 | 3.E-02 |
| | | | Cadmium | NA | -- | NA | NA | kidney | 5.E-02 | -- | 4.E-03 | 6.E-02 |
| | | | Chromium | NA | -- | NA | NA | NR | 9.E-02 | -- | 3.E-02 | 1.E-01 |
| | | | Cobalt | NA | -- | NA | NA | thyroid | 6.E-01 | -- | 8.E-04 | 6.E-01 |
| | | | Copper | NA | -- | NA | NA | GI | 1.E-02 | -- | 4.E-05 | 1.E-02 |
| | | | Iron | NA | -- | NA | NA | GI | 1.E+00 | -- | 4.E-03 | 1.E+00 |
| | | | Lead | NA | -- | NA | NA | NA | NA | -- | NA | NA |
| | | | Manganese | NA | -- | NA | NA | CNS | 9.E-01 | -- | 8.E-02 | 9.E-01 |
| | | | Nickel | NA | -- | NA | NA | body weight | 2.E-02 | -- | 4.E-04 | 2.E-02 |
| | | | Selenium | NA | -- | NA | NA | hair, nails, skin, blood, CNS | 3.E-02 | -- | 1.E-04 | 3.E-02 |
| | | | Silver | NA | -- | NA | NA | skin | 1.E-02 | -- | 1.E-03 | 1.E-02 |
| | | | Vanadium | NA | -- | NA | NA | hair | NA | -- | NA | NA |
| | | | Zinc | NA | -- | NA | NA | blood | NA | -- | NA | NA |
| | | | Chemical Total | 2.E-05 | -- | 3.E-07 | 2.E-05 | | 4.E+00 | -- | 1.E-01 | 4.E+00 |
| | | Exposure Point Total | | | | | 2.E-05 | | | | | 4.E+00 |
| | Exposure Medium Total | | | | | | 2.E-05 | | | | | 4.E+00 |

**Table 9.3.RME**
**Summary of Receptor Risks and Hazards for COPCs - Hypothetical Future Resident - Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child

| Medium | Exposure Medium | Exposure Point | Chemical of Potential Concern | Carcinogenic Risk | | | | Non-Carcinogenic Hazard Quotient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ingestion | Inhalation | Dermal | Exposure Routes Total | Primary Target Organ(s) | Ingestion | Inhalation | Dermal | Exposure Routes Total |
| Groundwater | Air | Shower Air | | | | | | | | | | |
| | | | **Volatile Organic Compounds (VOCs)** | | | | | | | | | |
| | | | 1,1-Dichloroethane | -- | 3.E-08 | -- | 3.E-08 | NA | -- | NA | -- | NA |
| | | | Benzene | -- | 2.E-07 | -- | 2.E-07 | immune system | -- | 1.E-02 | -- | 1.E-02 |
| | | | Methyl tert butyl ether | -- | 6.E-09 | -- | 6.E-09 | liver, kidney | -- | 8.E-05 | -- | 8.E-05 |
| | | | Toluene | -- | NA | -- | NA | neurological | -- | 2.E-04 | -- | 2.E-04 |
| | | | Trichloroethene | -- | 9.E-08 | -- | 9.E-08 | heart, development, immune system | -- | 3.E-02 | -- | 3.E-02 |
| | | | Xylenes | -- | NA | -- | NA | CNS | -- | NA | -- | NA |
| | | | **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | |
| | | | bis(2-Ethylhexyl)phthalate | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Naphthalene | -- | 2.E-07 | -- | 2.E-07 | nasal | -- | 2.E-02 | -- | 2.E-02 |
| | | | **Metals - Total** | | | | | | | | | |
| | | | Aluminum | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Arsenic | -- | NA | -- | NA | developmental, neurobehavioral | -- | NA | -- | NA |
| | | | Barium | -- | NA | -- | NA | fetus | -- | NA | -- | NA |
| | | | Cadmium | -- | NA | -- | NA | kidney, respiratory system | -- | NA | -- | NA |
| | | | Chromium | -- | NA | -- | NA | nasal | -- | NA | -- | NA |
| | | | Cobalt | -- | NA | -- | NA | lung | -- | NA | -- | NA |
| | | | Copper | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Iron | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Lead | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Manganese | -- | NA | -- | NA | neurological | -- | NA | -- | NA |
| | | | Nickel | -- | NA | -- | NA | respiratory system | -- | NA | -- | NA |
| | | | Selenium | -- | NA | -- | NA | hair, nails, skin, blood, CNS | -- | NA | -- | NA |
| | | | Silver | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Vanadium | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Zinc | -- | NA | -- | NA | NA | -- | NA | -- | NA |
| | | | Chemical Total | -- | 5.E-07 | -- | 5.E-07 | | -- | 6.E-02 | -- | 6.E-02 |
| | | Exposure Point Total | | | | | 5.E-07 | | | | | 6.E-02 |
| | Exposure Medium Total | | | | | | 5.E-07 | | | | | 6.E-02 |
| Medium Total | | | | | | | 2.E-05 | | | | | 4.E+00 |
| Receptor Total | | | | | | Receptor Risk Total | 2.E-05 | | | | Receptor HI Total | 4.E+00 |

**Acronyms and Abbreviations:**
-- = not an exposure route for this media
BHHRA = Baseline Human Health Risk Assessment
CNS = central nervous system
COPC = constituent of potential concern
GI = gastrointestinal tract
NA = not available or not applicable
NR = none reported

| | |
|---|---|
| Total Circulatory System (Blood, Heart, Vascular) HI Across All Media = | 0.7 |
| Total Reproductive/Developmental (Development, Developmental, Fetus) HI Across All Media = | 0.2 |
| Total GI HI Across All Media = | 1 |
| Total Immune System HI Across All Media = | 0.1 |
| Total Kidney HI Across All Media = | 0.1 |
| Total Liver HI Across All Media = | 0.01 |
| Total Nervous System (CNS, Neurobehavioral, Neurological) HI Across All Media = | 1 |
| Total "Not Reported" HI Across All Media = | 0.1 |
| Total Respiratory System (Lung, Nasal, Respiratory System) HI Across All Media = | 0.02 |
| Total Skin (Hair, Nails, Skin) HI Across All Media = | 0.6 |
| Total Thyroid HI Across All Media = | 0.6 |
| Total Whole Body (Body Weight, Mortality) HI Across All Media = | 0.02 |

**Table 11.1.CT**
**Summary of Estimated Potential Human Health Risks and Hazards**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| RECEPTOR<br>Exposure Medium - Scenario | Total Excess Lifetime Cancer Risk | Total Non-Cancer Hazard Index (1) | |
|---|---|---|---|
| Hypothetical Aggregate Future Resident | | | |
| Young Child (1-6 years) | 8E-06 | 1 | (2) |
| Youth (7-16 years) | 2E-06 | 0.6 | |
| Adult | NA | NA | |
| TOTAL SITE RISKS: | 1E-05 | -- | |

**Footnotes:**

(1) In accordance with standard risk assessment practice, estimated potential hazard indices are not summed across age groups to estimate "lifetime" hazard indices.

(2) Endpoint-specific hazard indices (HIs) for the receptor do not exceed a target HI of 1 for any endpoint evaluated (circulatory system; reproductive/developmental; GI; immune system; kidney; liver; musculoskeletal; nervous system; "not reported"; respiratory system; skin; thyroid; and whole body).

**Acronyms and Abbreviations:**

-- = not appropriate to sum non-cancer risks for different receptors
BHHRA = Baseline Human Health Risk Assessment
NA = not available or not applicable

**Table 11.1.RME**
**Summary of Estimated Potential Human Health Risks and Hazards**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

| **RECEPTOR** **Exposure Medium - Scenario** | **Total Excess Lifetime Cancer Risk** | **Total Non-Cancer Hazard Index (1)** | |
|---|---|---|---|
| Hypothetical Aggregate Future Resident | | | |
| Young Child (1-6 years) | 2E-05 | 4 | (2) |
| Youth (7-16 years) | 3E-05 | 3 | (2) |
| Adult | 7E-05 | 2 | (2) |
| TOTAL SITE RISKS: | 1E-04 | -- | |

**Footnotes:**

(1) In accordance with standard risk assessment practice, estimated potential hazard indices are not summed across age groups to estimate "lifetime" hazard indices.

(2) Endpoint-specific hazard indices (HIs) for the receptor do not exceed a target HI of 1 for any endpoint evaluated (circulatory system; reproductive/developmental; GI; immune system; kidney; liver; musculoskeletal; nervous system; "not reported"; respiratory system; skin; thyroid; and whole body).

**Acronyms and Abbreviations:**

-- = not appropriate to sum non-cancer risks for different receptors
BHHRA = Baseline Human Health Risk Assessment

**Table 12.1.CT**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

LEAD MODEL FOR WINDOWS Version 1.1

**INPUTS:**

**AIR**

| Age | Time Outdoors (hours) | Ventilation Rate ($m^3$/day) | Lung Absorption (%) | Outdoor Air Pb Concentration (µg Pb/$m^3$) |
|---|---|---|---|---|
| 0.5-1 | 0 | 2 | 0 | 0.1 |
| 1-2 | 2 | 3 | 32 | 0.1 |
| 2-3 | 3 | 5 | 32 | 0.1 |
| 3-4 | 4 | 5 | 32 | 0.1 |
| 4-5 | 4 | 5 | 32 | 0.1 |
| 5-6 | 4 | 7 | 32 | 0.1 |
| 6-7 | 4 | 7 | 32 | 0.1 |

Indoor Air Pb Concentration: 30.000 percent of outdoor.

**DIET**

| Age | Diet Intake (µg/day) |
|---|---|
| 0.5-1 | 0 |
| 1-2 | 1.960 |
| 2-3 | 2.130 |
| 3-4 | 2.040 |
| 4-5 | 1.950 |
| 5-6 | 2.050 |
| 6-7 | 2.220 |

**DRINKING WATER**

| Age | Water Consumption (L/day) |
|---|---|
| 0.5-1 | 0 |
| 1-2 | 0.330 |
| 2-3 | 0.330 |
| 3-4 | 0.330 |
| 4-5 | 0.330 |
| 5-6 | 0.330 |
| 6-7 | 0.330 |

Drinking Water Concentration: 2.300 µg Pb/L

**Table 12.1.CT**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**SOIL & DUST**

| Age | Soil (µg Pb/g) | House Dust (µg Pb/g) |
|---|---|---|
| 0.5-1 | 0 | 0 |
| 1-2 | 200 | 150 |
| 2-3 | 200 | 150 |
| 3-4 | 200 | 150 |
| 4-5 | 200 | 150 |
| 5-6 | 200 | 150 |
| 6-7 | 200 | 150 |

Multiple Source Analysis Used
Average multiple source concentration: 150.000 µg/g
Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

**ALTERNATE INTAKE**

| Age | Alternate (µg Pb/day) |
|---|---|
| 0.5-1 | 0 |
| 1-2 | 0 |
| 2-3 | 0 |
| 3-4 | 0 |
| 4-5 | 0 |
| 5-6 | 0 |
| 6-7 | 0 |

**MATERNAL CONTRIBUTION: INFANT MODEL**
Maternal Blood Concentration: 1.000 µg Pb/dL

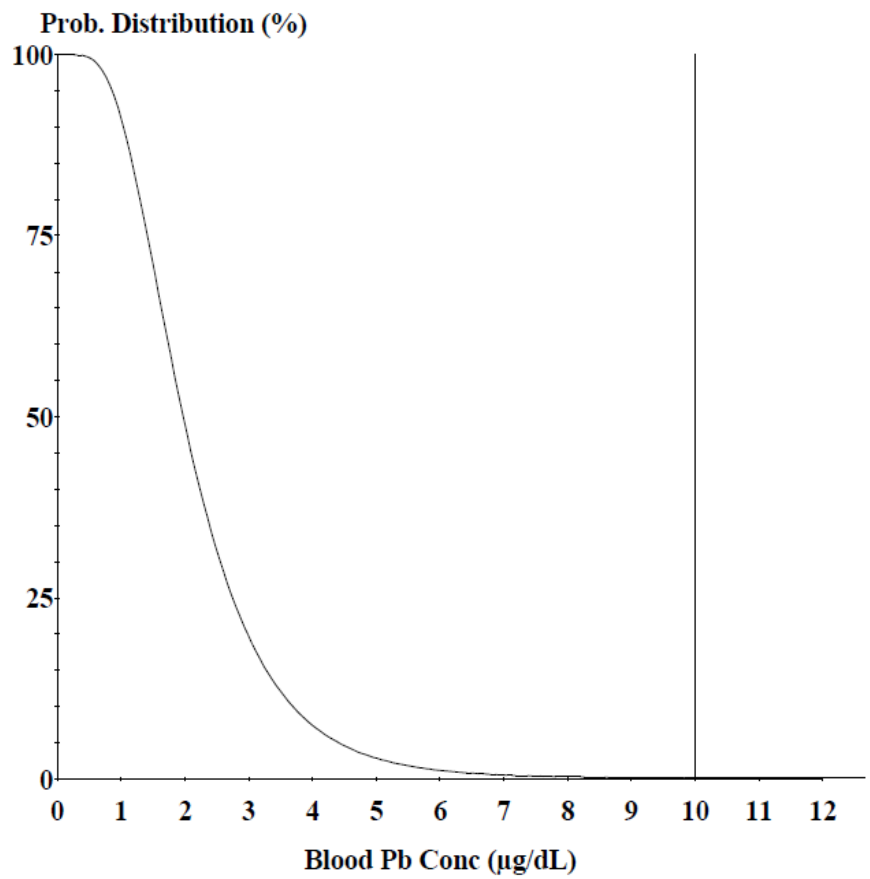
**CALCULATED BLOOD LEAD AND LEAD UPTAKES:**

| Age | Air (µg/day) | Diet (µg/day) | Alternate (µg/day) | Water (µg/day) | Soil + Dust (µg/day) | Total (µg/day) | Blood (µg/dL) |
|---|---|---|---|---|---|---|---|
| 0.5-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-2 | 0.034 | 0.915 | 0 | 0.354 | 6.524 | 7.828 | 2.8 |
| 2-3 | 0.062 | 1.004 | 0 | 0.358 | 6.585 | 8.008 | 3 |
| 3-4 | 0.067 | 0.97 | | 0.361 | 6.641 | 8.038 | 2.8 |
| 4-5 | 0.067 | 0.942 | 0 | 0.367 | 5 | 6.375 | 2.3 |
| 5-6 | 0.093 | 0.996 | 0 | 0.369 | 4.527 | 5.985 | 1.9 |
| 6-7 | 0.093 | 1.082 | 0 | 0.37 | 4.288 | 5.833 | 1.7 |

**Table 12.1.CT**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**RESULTS:**
**Probability Distribution**




Cutoff = 10.000 µg/dl
Geo Mean = 2.070
GSD = 1.600
% Above = 0.040

Age Range = 0 to 84 months

Run Mode = Research

**Table 12.1.CT**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Central Tendency Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**Acronyms and Abbreviations:**

% = percent
BHHRA = Baseline Human Health Risk Assessment
CT = central tendency
IEUBK = Integrated Exposure Uptake Biokinetic
GSD = geometric stanard deviation
L/day = liter per day
$m^3$/day = cubic meter per day
Pb = lead
µg Pb/day = microgram of lead per day
µg Pb/dL = microgram of lead per deciliter
µg Pb/g = microgram of lead per gram
µg Pb/L = microgram of lead per liter
µg Pb/$m^3$ = microgram of lead per cubic meter
µg/day = microgram per day
µg/g = microgram per gram

**Table 12.1.RME**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

LEAD MODEL FOR WINDOWS Version 1.1

**INPUTS:**

**AIR**

| Age | Time Outdoors (hours) | Ventilation Rate ($m^3$/day) | Lung Absorption (%) | Outdoor Air Pb Concentration (µg Pb/$m^3$) |
|---|---|---|---|---|
| 0.5-1 | 0 | 2 | 0 | 0.1 |
| 1-2 | 2 | 3 | 32 | 0.1 |
| 2-3 | 3 | 5 | 32 | 0.1 |
| 3-4 | 4 | 5 | 32 | 0.1 |
| 4-5 | 4 | 5 | 32 | 0.1 |
| 5-6 | 4 | 7 | 32 | 0.1 |
| 6-7 | 4 | 7 | 32 | 0.1 |

Indoor Air Pb Concentration: 30.000 percent of outdoor.

**DIET**

| Age | Diet Intake (µg/day) |
|---|---|
| 0.5-1 | 0 |
| 1-2 | 1.960 |
| 2-3 | 2.130 |
| 3-4 | 2.040 |
| 4-5 | 1.950 |
| 5-6 | 2.050 |
| 6-7 | 2.220 |

**DRINKING WATER**

| Age | Water Consumption (L/day) |
|---|---|
| 0.5-1 | 0 |
| 1-2 | 1.000 |
| 2-3 | 1.000 |
| 3-4 | 1.000 |
| 4-5 | 1.000 |
| 5-6 | 1.000 |
| 6-7 | 1.000 |

Drinking Water Concentration: 2.300 µg Pb/L

**Table 12.1.RME**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**SOIL & DUST**

| Age | Soil (µg Pb/g) | House Dust (µg Pb/g) |
|---|---|---|
| 0.5-1 | 0 | 0 |
| 1-2 | 200 | 150 |
| 2-3 | 200 | 150 |
| 3-4 | 200 | 150 |
| 4-5 | 200 | 150 |
| 5-6 | 200 | 150 |
| 6-7 | 200 | 150 |

Multiple Source Analysis Used
Average multiple source concentration: 150.000 µg/g
Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

**ALTERNATE INTAKE**

| Age | Alternate (µg Pb/day) |
|---|---|
| 0.5-1 | 0 |
| 1-2 | 0 |
| 2-3 | 0 |
| 3-4 | 0 |
| 4-5 | 0 |
| 5-6 | 0 |
| 6-7 | 0 |

**MATERNAL CONTRIBUTION: INFANT MODEL**
Maternal Blood Concentration: 1.000 µg Pb/dL

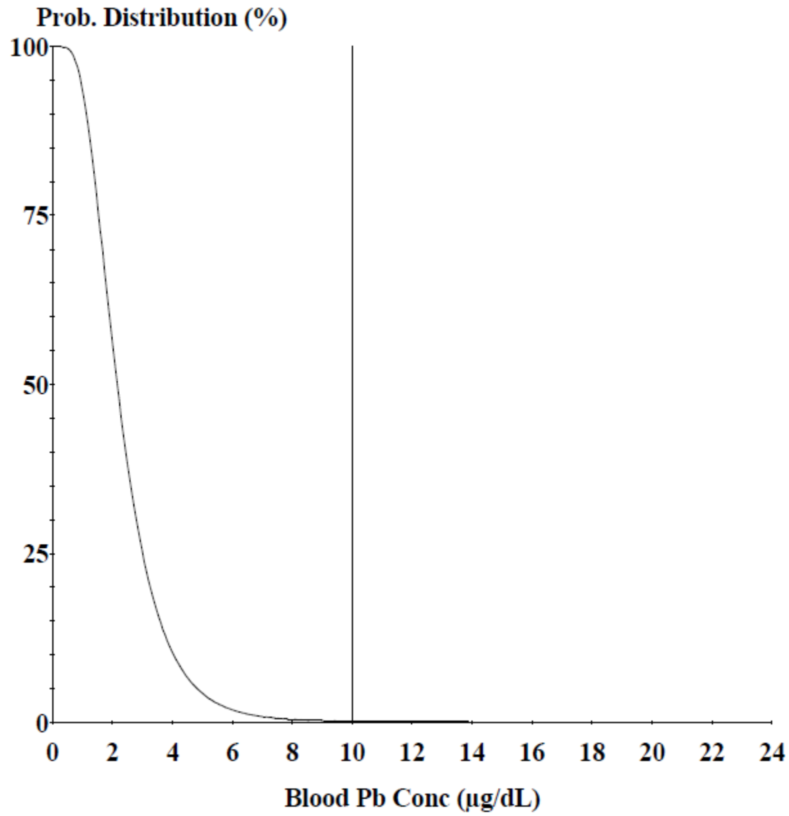
**CALCULATED BLOOD LEAD AND LEAD UPTAKES:**

| Age | Air (µg/day) | Diet (µg/day) | Alternate (µg/day) | Water (µg/day) | Soil + Dust (µg/day) | Total (µg/day) | Blood (µg/dL) |
|---|---|---|---|---|---|---|---|
| 0.5-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-2 | 0.034 | 0.91 | 0 | 1.068 | 6.486 | 8.497 | 3 |
| 2-3 | 0.062 | 0.999 | 0 | 1.078 | 6.551 | 8.69 | 3.2 |
| 3-4 | 0.067 | 0.965 | | 1.088 | 6.612 | 8.732 | 3.1 |
| 4-5 | 0.067 | 0.938 | 0 | 1.107 | 4.98 | 7.092 | 2.5 |
| 5-6 | 0.093 | 0.993 | 0 | 1.114 | 4.511 | 6.71 | 2.1 |
| 6-7 | 0.093 | 1.079 | 0 | 1.117 | 4.274 | 6.563 | 1.9 |

**Table 12.1.RME**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Reasonable Maximum Exposure**

**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**RESULTS:**
**Probability Distribution**




Cutoff = 10.000 µg/dl
Geo Mean = 2.266
GSD = 1.600
% Above = 0.079

Age Range = 0 to 84 months

Run Mode = Research

**Table 12.1.RME**
**Calculations of Blood Lead Concentrations (IEUBK) – Hypothetical Future Resident – Young Child**
**Reasonable Maximum Exposure**

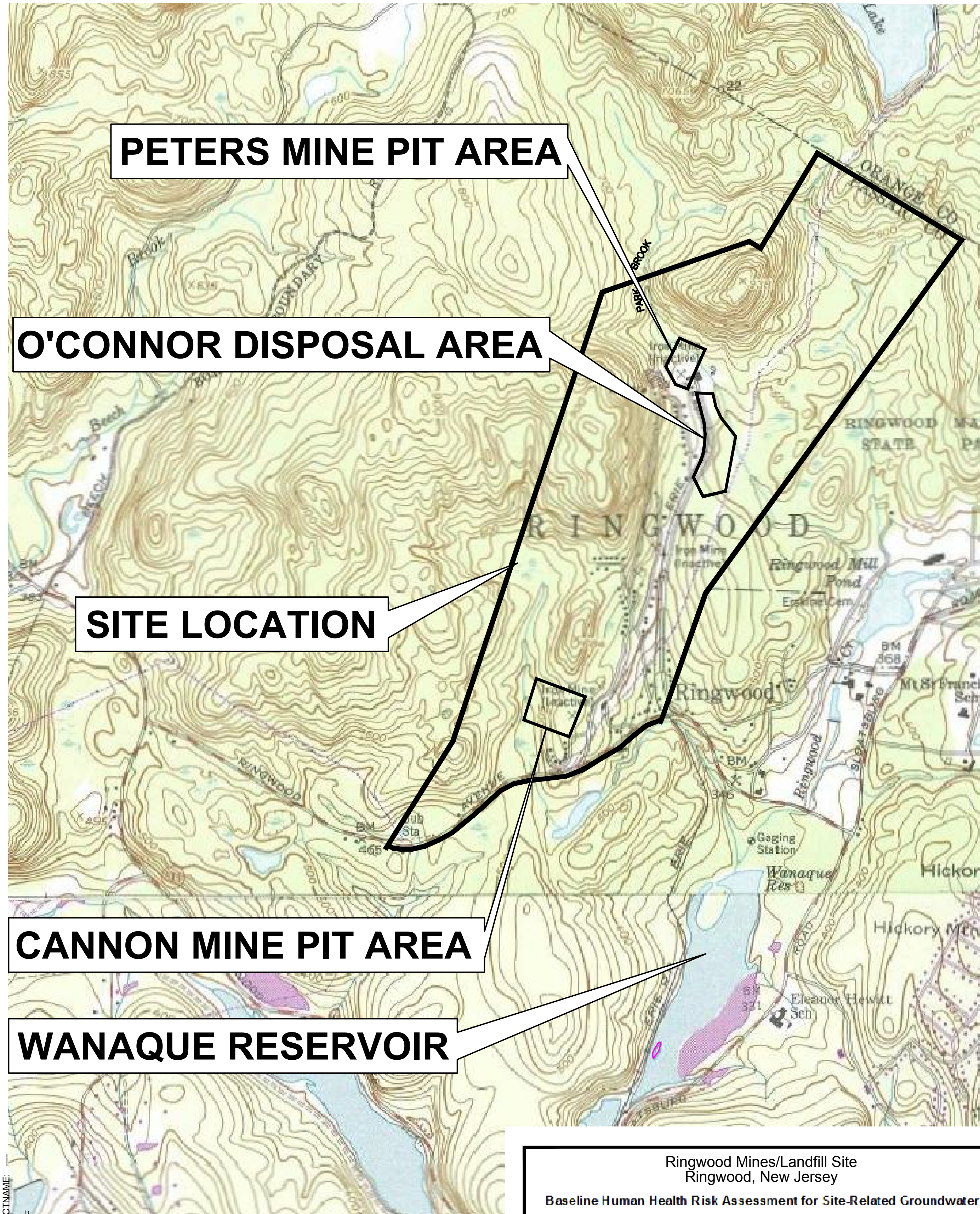
**Site-Related Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**Acronyms and Abbreviations:**

% = percent
BHHRA = Baseline Human Health Risk Assessment
RME = reasonable maximum exposure
IEUBK = Integrated Exposure Uptake Biokinetic
GSD = geometric stanard deviation
L/day = liter per day
$m^3$/day = cubic meter per day
Pb = lead
µg Pb/day = microgram of lead per day
µg Pb/dL = microgram of lead per deciliter
µg Pb/g = microgram of lead per gram
µg Pb/L = microgram of lead per liter
µg Pb/$m^3$ = microgram of lead per cubic meter
µg/day = microgram per day
µg/g = microgram per gram

ARCADIS

# Figures




REFERENCE: WANAQUE, NJ AND GREENWOOD LAKE, NY–NJ, USGS QUADRANGLE, 7.5 MINUTE SERIES, 1995 AND 1954.

0 2000

SCALE IN FEET

LEGEND:

SITE BOUNDARY

Ringwood Mines/Landfill Site
Ringwood, New Jersey

**Baseline Human Health Risk Assessment for Site-Related Groundwater**

**SITE LOCATION**

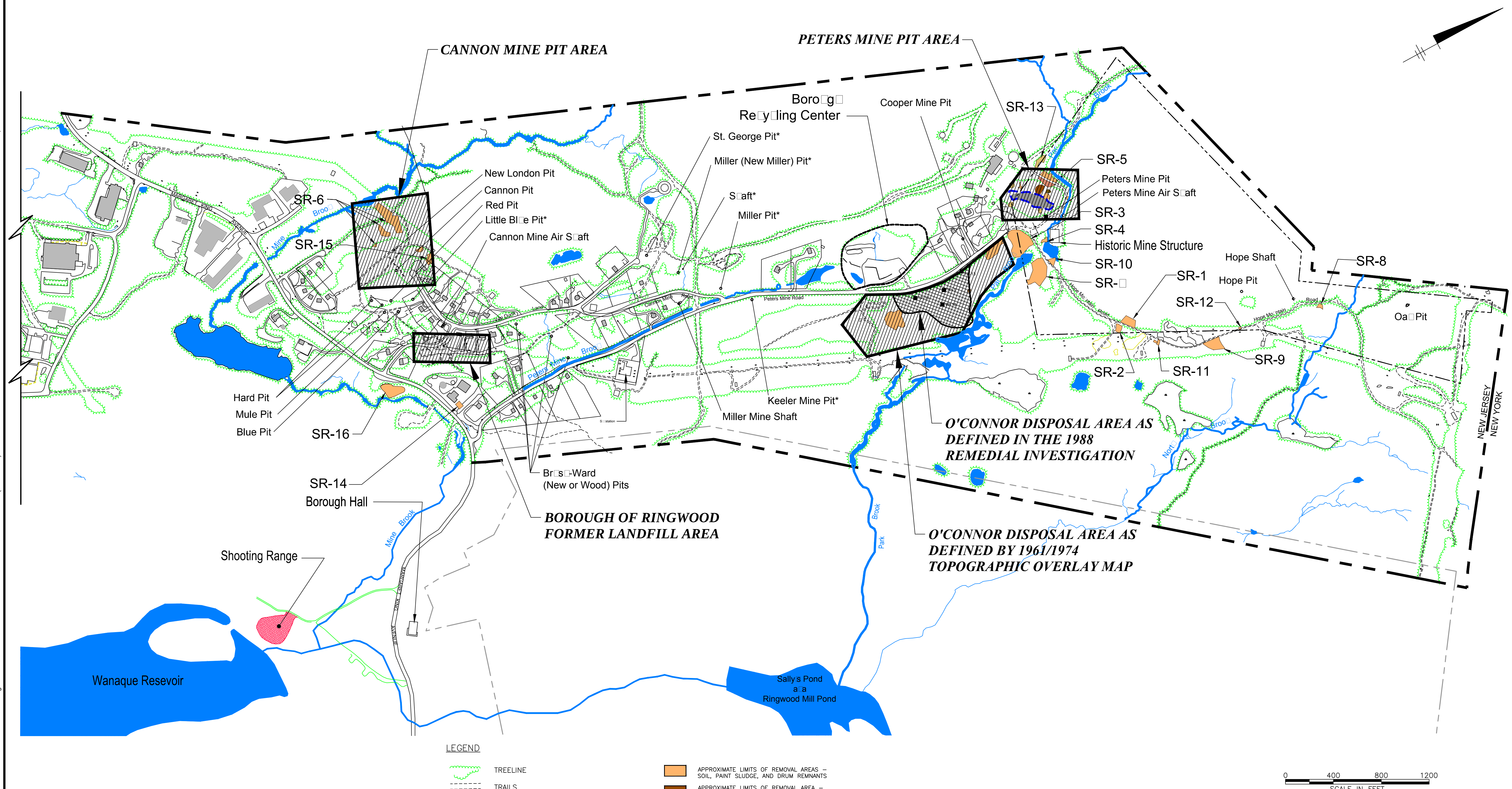
ARCADIS

FIGURE

**1**

CITY:MAHWAH DIV/GROUP:ENVCAD DB:JG LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Newtown\ACT\RETURN-TO\Fairlawn-NJ\NJ000604\2013\00035\2014-02\GW\FIG-01 - SITE LOCATION MAP.dwg LAYOUT: 1 SAVED: 2/28/2014 2:44 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ARCADIS.CTB PLOTTED: 2/28/2014 2:44 PM BY: WASILEWSKI, MATT

XREFS: IMAGES: 00604X01.JPG GREENWOOD-NJ.TIF Ring0001.JPG PROJECTNAME: ---




LEGEND

- TREELINE
- TRAILS
- ROADWAYS
- SURFACE WATER
- RINGWOOD STATE PARK BOUNDARY
- BUILDINGS
- TRANSMISSION LINE TOWER
- UTILITY POLE
- FORMER TEST PIT LOCATION
- FORMER MINE SHAFT ENTRANCE
- APPROXIMATE LIMITS OF REMOVAL AREAS – SOIL, PAINT SLUDGE, AND DRUM REMNANTS
- APPROXIMATE LIMITS OF REMOVAL AREA – SOIL AND DRUM REMNANTS
- APPROXIMATE LIMITS OF REMOVAL AREA – SOIL, DRUMS, AND DRUM REMNANTS
- APPROXIMATE LIMITS OF REMOVAL AREAS – SOIL AND PAINT SLUDGE
- APPROXIMATE LIMITS OF SURFICIAL SOIL SCRAPING

| Re isions | | |
|---|---|---|
| No. | Date | By |
| 1 | 2/2 /2014 | P. Ma iaroli |

Ringwood Mines/Landfill Site
Ringwood, New Jersey

**Baseline Human Health Risk Assessment for Site-Related Groundwater**

**SITE LAYOUT**

ARCADIS

FIGURE
**2**

ARCADIS

## Appendix A

ProUCL Output

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (1,1-dichloroethane)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 455 | Number of Distinct Observations | 49 |
| Number of Detects | 60 | Number of Non-Detects | 395 |
| Number of Distinct Detects | 45 | Number of Distinct Non-Detects | 6 |
| Minimum Detect | 0.23 | Minimum Non-Detect | 0.16 |
| Maximum Detect | 89.3 | Maximum Non-Detect | 0.35 |
| Variance Detects | 142.3 | Percent Non-Detects | 86.81% |
| Mean Detects | 2.654 | SD Detects | 11.93 |
| Median Detects | 0.625 | CV Detects | 4.494 |
| Skewness Detects | 6.887 | Kurtosis Detects | 49.46 |
| Mean of Logged Detects | -0.323 | SD of Logged Detects | 0.938 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.2 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.485 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.114 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.49 | Standard Error of Mean | 0.207 |
| SD | 4.378 | 95% KM (BCA) UCL | 0.881 |
| 95% KM (t) UCL | 0.831 | 95% KM (Percentile Bootstrap) UCL | 0.875 |
| 95% KM (z) UCL | 0.83 | 95% KM Bootstrap t UCL | 5.438 |
| 90% KM Chebyshev UCL | 1.11 | 95% KM Chebyshev UCL | 1.392 |
| 97.5% KM Chebyshev UCL | 1.782 | 99% KM Chebyshev UCL | 2.549 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 14.03 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.818 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.419 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.122 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.49 | k star (bias corrected MLE) | 0.477 |
| Theta hat (MLE) | 5.414 | Theta star (bias corrected MLE) | 5.566 |
| nu hat (MLE) | 58.84 | nu star (bias corrected) | 57.23 |
| MLE Mean (bias corrected) | 2.654 | MLE Sd (bias corrected) | 3.844 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0125 | nu hat (KM) | 11.38 |
| Approximate Chi Square Value (11.38, α) | 4.822 | Adjusted Chi Square Value (11.38, β) | 4.808 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 1.156 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1.159 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.359 |
| Maximum | 89.3 | Median | 0.01 |
| SD | 4.393 | CV | 12.25 |
| k hat (MLE) | 0.238 | k star (bias corrected MLE) | 0.237 |
| Theta hat (MLE) | 1.51 | Theta star (bias corrected MLE) | 1.511 |
| nu hat (MLE) | 216.1 | nu star (bias corrected) | 216 |
| MLE Mean (bias corrected) | 0.359 | MLE Sd (bias corrected) | 0.736 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (216.04, α) | 183 | Adjusted Chi Square Value (216.04, β) | 182.9 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.423 | 95% Gamma Adjusted UCL (use when n<50) | 0.424 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.249 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.114 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.388 | Mean in Log Scale | -3.574 |
| SD in Original Scale | 4.391 | SD in Log Scale | 1.976 |
| 95% t UCL (assumes normality of ROS data) | 0.727 | 95% Percentile Bootstrap UCL | 0.778 |
| 95% BCA Bootstrap UCL | 1.11 | 95% Bootstrap t UCL | 4.913 |
| 95% H-UCL (Log ROS) | 0.262 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.461 | Mean in Log Scale | -1.854 |
| SD in Original Scale | 4.385 | SD in Log Scale | 0.724 |
| 95% t UCL (Assumes normality) | 0.8 | 95% H-Stat UCL | 0.217 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 0.831 | 95% KM (% Bootstrap) UCL | 0.875 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (aluminum)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 279 |
| Number of Detects | 297 | Number of Non-Detects | 151 |
| Number of Distinct Detects | 270 | Number of Distinct Non-Detects | 11 |
| Minimum Detect | 11.2 | Minimum Non-Detect | 7.2 |
| Maximum Detect | 43100 | Maximum Non-Detect | 254 |
| Variance Detects | 18048452 | Percent Non-Detects | 33.71% |
| Mean Detects | 1042 | SD Detects | 4248 |
| Median Detects | 174 | CV Detects | 4.076 |
| Skewness Detects | 7.593 | Kurtosis Detects | 62.73 |
| Mean of Logged Detects | 5.366 | SD of Logged Detects | 1.436 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.241 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.404 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0514 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 699 | Standard Error of Mean | 165 |
| SD | 3487 | 95% KM (BCA) UCL | 997.1 |
| 95% KM (t) UCL | 971 | 95% KM (Percentile Bootstrap) UCL | 979.1 |
| 95% KM (z) UCL | 970.4 | 95% KM Bootstrap t UCL | 1107 |
| 90% KM Chebyshev UCL | 1194 | 95% KM Chebyshev UCL | 1418 |
| 97.5% KM Chebyshev UCL | 1729 | 99% KM Chebyshev UCL | 2341 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 29.24 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.843 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.224 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0561 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.414 | k star (bias corrected MLE) | 0.412 |
| Theta hat (MLE) | 2520 | Theta star (bias corrected MLE) | 2532 |
| nu hat (MLE) | 245.6 | nu star (bias corrected) | 244.5 |
| MLE Mean (bias corrected) | 1042 | MLE Sd (bias corrected) | 1624 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0402 | nu hat (KM) | 36.01 |
| Approximate Chi Square Value (36.01, α) | 23.28 | Adjusted Chi Square Value (36.01, β) | 23.24 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 1081 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1083 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 690.9 |
| Maximum | 43100 | Median | 69.4 |
| SD | 3492 | CV | 5.054 |
| k hat (MLE) | 0.167 | k star (bias corrected MLE) | 0.167 |
| Theta hat (MLE) | 4139 | Theta star (bias corrected MLE) | 4130 |
| nu hat (MLE) | 149.6 | nu star (bias corrected) | 149.9 |
| MLE Mean (bias corrected) | 690.9 | MLE Sd (bias corrected) | 1689 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (149.89, α) | 122.6 | Adjusted Chi Square Value (149.89, β) | 122.5 |
| 95% Gamma Approximate UCL (use when n>=50) | 844.8 | 95% Gamma Adjusted UCL (use when n<50) | 845.3 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0876 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0514 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 699.2 | Mean in Log Scale | 4.393 |
| SD in Original Scale | 3491 | SD in Log Scale | 1.927 |
| 95% t UCL (assumes normality of ROS data) | 971 | 95% Percentile Bootstrap UCL | 995.4 |
| 95% BCA Bootstrap UCL | 1093 | 95% Bootstrap t UCL | 1131 |
| 95% H-UCL (Log ROS) | 680.1 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 704.6 | Mean in Log Scale | 4.597 |
| SD in Original Scale | 3490 | SD in Log Scale | 1.72 |
| 95% t UCL (Assumes normality) | 976.3 | 95% H-Stat UCL | 545.3 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (Chebyshev) UCL 1418

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (arsenic)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 79 |
| Number of Detects | 134 | Number of Non-Detects | 314 |
| Number of Distinct Detects | 77 | Number of Distinct Non-Detects | 10 |
| Minimum Detect | 1.1 | Minimum Non-Detect | 0.92 |
| Maximum Detect | 26.6 | Maximum Non-Detect | 5.9 |
| Variance Detects | 34.32 | Percent Non-Detects | 70.09% |
| Mean Detects | 5.846 | SD Detects | 5.858 |
| Median Detects | 3.6 | CV Detects | 1.002 |
| Skewness Detects | 2.145 | Kurtosis Detects | 4.062 |
| Mean of Logged Detects | 1.419 | SD of Logged Detects | 0.787 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.691 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.216 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0765 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 2.463 | Standard Error of Mean | 0.185 |
| SD | 3.891 | 95% KM (BCA) UCL | 2.778 |
| 95% KM (t) UCL | 2.768 | 95% KM (Percentile Bootstrap) UCL | 2.771 |
| 95% KM (z) UCL | 2.767 | 95% KM Bootstrap t UCL | 2.815 |
| 90% KM Chebyshev UCL | 3.018 | 95% KM Chebyshev UCL | 3.27 |
| 97.5% KM Chebyshev UCL | 3.619 | 99% KM Chebyshev UCL | 4.305 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 4.964 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.769 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.151 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0821 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.587 | k star (bias corrected MLE) | 1.556 |
| Theta hat (MLE) | 3.684 | Theta star (bias corrected MLE) | 3.756 |
| nu hat (MLE) | 425.3 | nu star (bias corrected) | 417.1 |
| MLE Mean (bias corrected) | 5.846 | MLE Sd (bias corrected) | 4.686 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.401 | nu hat (KM) | 359 |
| Approximate Chi Square Value (359.01, α) | 316.1 | Adjusted Chi Square Value (359.01, β) | 316 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.797 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.798 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 1.798 |
| Maximum | 26.6 | Median | 0.01 |
| SD | 4.157 | CV | 2.311 |
| k hat (MLE) | 0.225 | k star (bias corrected MLE) | 0.225 |
| Theta hat (MLE) | 8.009 | Theta star (bias corrected MLE) | 8.01 |
| nu hat (MLE) | 201.2 | nu star (bias corrected) | 201.2 |
| MLE Mean (bias corrected) | 1.798 | MLE Sd (bias corrected) | 3.795 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (201.18, α) | 169.4 | Adjusted Chi Square Value (201.18, β) | 169.3 |
| 95% Gamma Approximate UCL (use when n>=50) | 2.136 | 95% Gamma Adjusted UCL (use when n<50) | 2.138 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.102 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0765 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 2.175 | Mean in Log Scale | -0.204 |
| SD in Original Scale | 4.02 | SD in Log Scale | 1.408 |
| 95% t UCL (assumes normality of ROS data) | 2.488 | 95% Percentile Bootstrap UCL | 2.494 |
| 95% BCA Bootstrap UCL | 2.532 | 95% Bootstrap t UCL | 2.537 |
| 95% H-UCL (Log ROS) | 2.586 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 2.407 | Mean in Log Scale | 0.329 |
| SD in Original Scale | 3.919 | SD in Log Scale | 0.894 |
| 95% t UCL (Assumes normality) | 2.712 | 95% H-Stat UCL | 2.258 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 2.768 | 95% KM (% Bootstrap) UCL | 2.771 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (barium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 346 |
| Number of Detects | 431 | Number of Non-Detects | 17 |
| Number of Distinct Detects | 344 | Number of Distinct Non-Detects | 4 |
| Minimum Detect | 1.7 | Minimum Non-Detect | 3.7 |
| Maximum Detect | 1570 | Maximum Non-Detect | 200 |
| Variance Detects | 17922 | Percent Non-Detects | 3.795% |
| Mean Detects | 67.78 | SD Detects | 133.9 |
| Median Detects | 26.8 | CV Detects | 1.975 |
| Skewness Detects | 5.541 | Kurtosis Detects | 45.34 |
| Mean of Logged Detects | 3.34 | SD of Logged Detects | 1.258 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.483 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.311 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0427 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 66.38 | Standard Error of Mean | 6.228 |
| SD | 131.5 | 95% KM (BCA) UCL | 78.06 |
| 95% KM (t) UCL | 76.64 | 95% KM (Percentile Bootstrap) UCL | 77.08 |
| 95% KM (z) UCL | 76.62 | 95% KM Bootstrap t UCL | 79.59 |
| 90% KM Chebyshev UCL | 85.06 | 95% KM Chebyshev UCL | 93.52 |
| 97.5% KM Chebyshev UCL | 105.3 | 99% KM Chebyshev UCL | 128.3 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 15.82 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.803 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.137 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0457 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.691 | k star (bias corrected MLE) | 0.688 |
| Theta hat (MLE) | 98.11 | Theta star (bias corrected MLE) | 98.57 |
| nu hat (MLE) | 595.5 | nu star (bias corrected) | 592.7 |
| MLE Mean (bias corrected) | 67.78 | MLE Sd (bias corrected) | 81.74 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.255 | nu hat (KM) | 228.2 |
| Approximate Chi Square Value (228.24, α) | 194.3 | Adjusted Chi Square Value (228.24, β) | 194.2 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 77.98 | 95% Gamma Adjusted KM-UCL (use when n<50) | 78.02 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 66.58 |
| Maximum | 1570 | Median | 26.65 |
| SD | 131.9 | CV | 1.98 |
| k hat (MLE) | 0.616 | k star (bias corrected MLE) | 0.614 |
| Theta hat (MLE) | 108.1 | Theta star (bias corrected MLE) | 108.5 |
| nu hat (MLE) | 552.1 | nu star (bias corrected) | 549.7 |
| MLE Mean (bias corrected) | 66.58 | MLE Sd (bias corrected) | 85 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (549.74, α) | 496.4 | Adjusted Chi Square Value (549.74, β) | 496.2 |
| 95% Gamma Approximate UCL (use when n>=50) | 73.74 | 95% Gamma Adjusted UCL (use when n<50) | 73.77 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0416 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0427 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Approximate Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 66.34 | Mean in Log Scale | 3.322 |
| SD in Original Scale | 131.6 | SD in Log Scale | 1.256 |
| 95% t UCL (assumes normality of ROS data) | 76.59 | 95% Percentile Bootstrap UCL | 77.06 |
| 95% BCA Bootstrap UCL | 78.14 | 95% Bootstrap t UCL | 78.92 |
| 95% H-UCL (Log ROS) | 69.99 | | |

**UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed**

| | | | |
|---|---|---|---|
| KM Mean (logged) | 3.321 | 95% H-UCL (KM -Log) | 69.96 |
| KM SD (logged) | 1.256 | 95% Critical H Value (KM-Log) | 2.321 |
| KM Standard Error of Mean (logged) | 0.0601 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 68.37 | Mean in Log Scale | 3.367 |
| SD in Original Scale | 131.5 | SD in Log Scale | 1.265 |
| 95% t UCL (Assumes normality) | 78.61 | 95% H-Stat UCL | 74.17 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Approximate Lognormal Distributed at 5% Significance Level**

**Suggested UCL to Use**

95% KM (Chebyshev) UCL 93.52

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (benzene)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 455 | Number of Distinct Observations | 70 |
| Number of Detects | 86 | Number of Non-Detects | 369 |
| Number of Distinct Detects | 65 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.23 | Minimum Non-Detect | 0.05 |
| Maximum Detect | 88.1 | Maximum Non-Detect | 6 |
| Variance Detects | 145.7 | Percent Non-Detects | 81.1% |
| Mean Detects | 4.29 | SD Detects | 12.07 |
| Median Detects | 1.2 | CV Detects | 2.813 |
| Skewness Detects | 5.411 | Kurtosis Detects | 31.98 |
| Mean of Logged Detects | 0.317 | SD of Logged Detects | 1.265 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.35 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.368 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0955 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.853 | Standard Error of Mean | 0.258 |
| SD | 5.474 | 95% KM (BCA) UCL | 1.495 |
| 95% KM (t) UCL | 1.278 | 95% KM (Percentile Bootstrap) UCL | 1.388 |
| 95% KM (z) UCL | 1.278 | 95% KM Bootstrap t UCL | 1.671 |
| 90% KM Chebyshev UCL | 1.627 | 95% KM Chebyshev UCL | 1.978 |
| 97.5% KM Chebyshev UCL | 2.465 | 99% KM Chebyshev UCL | 3.421 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 7.087 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.814 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.226 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.102 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.549 | k star (bias corrected MLE) | 0.538 |
| Theta hat (MLE) | 7.81 | Theta star (bias corrected MLE) | 7.976 |
| nu hat (MLE) | 94.49 | nu star (bias corrected) | 92.53 |
| MLE Mean (bias corrected) | 4.29 | MLE Sd (bias corrected) | 5.85 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0243 | nu hat (KM) | 22.09 |
| Approximate Chi Square Value (22.09, α) | 12.41 | Adjusted Chi Square Value (22.09, β) | 12.38 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 1.519 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1.522 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.819 |
| Maximum | 88.1 | Median | 0.01 |
| SD | 5.485 | CV | 6.697 |
| k hat (MLE) | 0.21 | k star (bias corrected MLE) | 0.21 |
| Theta hat (MLE) | 3.898 | Theta star (bias corrected MLE) | 3.896 |
| nu hat (MLE) | 191.2 | nu star (bias corrected) | 191.3 |
| MLE Mean (bias corrected) | 0.819 | MLE Sd (bias corrected) | 1.786 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (191.29, α) | 160.3 | Adjusted Chi Square Value (191.29, β) | 160.2 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.977 | 95% Gamma Adjusted UCL (use when n<50) | 0.978 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0893 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0955 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Approximate Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.845 | Mean in Log Scale | -3.645 |
| SD in Original Scale | 5.482 | SD in Log Scale | 2.725 |
| 95% t UCL (assumes normality of ROS data) | 1.269 | 95% Percentile Bootstrap UCL | 1.296 |
| 95% BCA Bootstrap UCL | 1.546 | 95% Bootstrap t UCL | 1.726 |
| 95% H-UCL (Log ROS) | 1.778 | | |

**UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -2.361 | 95% H-UCL (KM -Log) | 0.3 |
| KM SD (logged) | 1.409 | 95% Critical H Value (KM-Log) | 2.462 |
| KM Standard Error of Mean (logged) | 0.0668 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.914 | Mean in Log Scale | -1.665 |
| SD in Original Scale | 5.473 | SD in Log Scale | 1.119 |
| 95% t UCL (Assumes normality) | 1.337 | 95% H-Stat UCL | 0.397 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Approximate Lognormal Distributed at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 1.495

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (bis(2-ethylhexyl)phthalate)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 439 | Number of Distinct Observations | 91 |
| Number of Detects | 37 | Number of Non-Detects | 402 |
| Number of Distinct Detects | 27 | Number of Distinct Non-Detects | 70 |
| Minimum Detect | 1.2 | Minimum Non-Detect | 0.33 |
| Maximum Detect | 156 | Maximum Non-Detect | 17.1 |
| Variance Detects | 640.6 | Percent Non-Detects | 91.57% |
| Mean Detects | 7.846 | SD Detects | 25.31 |
| Median Detects | 2.6 | CV Detects | 3.226 |
| Skewness Detects | 5.884 | Kurtosis Detects | 35.27 |
| Mean of Logged Detects | 1.137 | SD of Logged Detects | 0.955 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.254 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.936 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.42 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.146 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.971 | Standard Error of Mean | 0.365 |
| SD | 7.543 | 95% KM (BCA) UCL | 1.716 |
| 95% KM (t) UCL | 1.573 | 95% KM (Percentile Bootstrap) UCL | 1.68 |
| 95% KM (z) UCL | 1.572 | 95% KM Bootstrap t UCL | 4.325 |
| 90% KM Chebyshev UCL | 2.067 | 95% KM Chebyshev UCL | 2.563 |
| 97.5% KM Chebyshev UCL | 3.251 | 99% KM Chebyshev UCL | 4.604 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 5.326 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.797 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.301 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.152 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.66 | k star (bias corrected MLE) | 0.625 |
| Theta hat (MLE) | 11.89 | Theta star (bias corrected MLE) | 12.56 |
| nu hat (MLE) | 48.85 | nu star (bias corrected) | 46.22 |
| MLE Mean (bias corrected) | 7.846 | MLE Sd (bias corrected) | 9.928 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0166 | nu hat (KM) | 14.56 |
| Approximate Chi Square Value (14.56, α) | 6.957 | Adjusted Chi Square Value (14.56, β) | 6.94 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.033 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.038 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.67 |
| Maximum | 156 | Median | 0.01 |
| SD | 7.577 | CV | 11.3 |
| k hat (MLE) | 0.198 | k star (bias corrected MLE) | 0.198 |
| Theta hat (MLE) | 3.385 | Theta star (bias corrected MLE) | 3.382 |
| nu hat (MLE) | 173.9 | nu star (bias corrected) | 174 |
| MLE Mean (bias corrected) | 0.67 | MLE Sd (bias corrected) | 1.506 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (174.04, α) | 144.5 | Adjusted Chi Square Value (174.04, β) | 144.4 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.807 | 95% Gamma Adjusted UCL (use when n<50) | 0.808 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.806 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.936 | Detected Data Not Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.186 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.146 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.746 | Mean in Log Scale | -3.029 |
| SD in Original Scale | 7.571 | SD in Log Scale | 2.009 |
| 95% t UCL (assumes normality of ROS data) | 1.342 | 95% Percentile Bootstrap UCL | 1.447 |
| 95% BCA Bootstrap UCL | 2.123 | 95% Bootstrap t UCL | 3.8 |
| 95% H-UCL (Log ROS) | 0.489 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 1.063 | Mean in Log Scale | -1.009 |
| SD in Original Scale | 7.577 | SD in Log Scale | 0.963 |
| 95% t UCL (Assumes normality) | 1.659 | 95% H-Stat UCL | 0.637 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 1.573 | 95% KM (% Bootstrap) UCL | 1.68 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (cadmium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 29 |
| Number of Detects | 74 | Number of Non-Detects | 374 |
| Number of Distinct Detects | 25 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.2 | Minimum Non-Detect | 0.17 |
| Maximum Detect | 11.8 | Maximum Non-Detect | 3 |
| Variance Detects | 3.318 | Percent Non-Detects | 83.48% |
| Mean Detects | 1.153 | SD Detects | 1.822 |
| Median Detects | 0.6 | CV Detects | 1.579 |
| Skewness Detects | 4.514 | Kurtosis Detects | 22.49 |
| Mean of Logged Detects | -0.316 | SD of Logged Detects | 0.812 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.467 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.306 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.103 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.351 | Standard Error of Mean | 0.0397 |
| SD | 0.826 | 95% KM (BCA) UCL | 0.416 |
| 95% KM (t) UCL | 0.416 | 95% KM (Percentile Bootstrap) UCL | 0.418 |
| 95% KM (z) UCL | 0.416 | 95% KM Bootstrap t UCL | 0.46 |
| 90% KM Chebyshev UCL | 0.47 | 95% KM Chebyshev UCL | 0.524 |
| 97.5% KM Chebyshev UCL | 0.599 | 99% KM Chebyshev UCL | 0.746 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 5.083 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.776 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.21 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.106 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.23 | k star (bias corrected MLE) | 1.189 |
| Theta hat (MLE) | 0.937 | Theta star (bias corrected MLE) | 0.97 |
| nu hat (MLE) | 182.1 | nu star (bias corrected) | 176 |
| MLE Mean (bias corrected) | 1.153 | MLE Sd (bias corrected) | 1.058 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.18 | nu hat (KM) | 161.7 |
| Approximate Chi Square Value (161.72, α) | 133.3 | Adjusted Chi Square Value (161.72, β) | 133.2 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.426 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.426 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.216 |
| Maximum | 11.8 | Median | 0.01 |
| SD | 0.861 | CV | 3.992 |
| k hat (MLE) | 0.302 | k star (bias corrected MLE) | 0.301 |
| Theta hat (MLE) | 0.714 | Theta star (bias corrected MLE) | 0.715 |
| nu hat (MLE) | 270.6 | nu star (bias corrected) | 270.1 |
| MLE Mean (bias corrected) | 0.216 | MLE Sd (bias corrected) | 0.393 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (270.07, α) | 233 | Adjusted Chi Square Value (270.07, β) | 232.9 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.25 | 95% Gamma Adjusted UCL (use when n<50) | 0.25 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.135 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.103 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.264 | Mean in Log Scale | -2.694 |
| SD in Original Scale | 0.845 | SD in Log Scale | 1.624 |
| 95% t UCL (assumes normality of ROS data) | 0.33 | 95% Percentile Bootstrap UCL | 0.33 |
| 95% BCA Bootstrap UCL | 0.355 | 95% Bootstrap t UCL | 0.368 |
| 95% H-UCL (Log ROS) | 0.31 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 0.478 | Mean in Log Scale | -1.323 |
| SD in Original Scale | 0.891 | SD in Log Scale | 0.934 |
| 95% t UCL (Assumes normality) | 0.547 | 95% H-Stat UCL | 0.451 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 0.416 | 95% KM (% Bootstrap) UCL | 0.418 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (chromium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 447 | Number of Distinct Observations | 90 |
| Number of Detects | 181 | Number of Non-Detects | 266 |
| Number of Distinct Detects | 82 | Number of Distinct Non-Detects | 21 |
| Minimum Detect | 0.7 | Minimum Non-Detect | 0.53 |
| Maximum Detect | 113 | Maximum Non-Detect | 20.8 |
| Variance Detects | 239.1 | Percent Non-Detects | 59.51% |
| Mean Detects | 7.318 | SD Detects | 15.46 |
| Median Detects | 2.4 | CV Detects | 2.113 |
| Skewness Detects | 3.882 | Kurtosis Detects | 16.94 |
| Mean of Logged Detects | 1.095 | SD of Logged Detects | 1.116 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.452 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.346 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0659 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 3.461 | Standard Error of Mean | 0.492 |
| SD | 10.35 | 95% KM (BCA) UCL | 4.338 |
| 95% KM (t) UCL | 4.272 | 95% KM (Percentile Bootstrap) UCL | 4.304 |
| 95% KM (z) UCL | 4.271 | 95% KM Bootstrap t UCL | 4.477 |
| 90% KM Chebyshev UCL | 4.938 | 95% KM Chebyshev UCL | 5.607 |
| 97.5% KM Chebyshev UCL | 6.535 | 99% KM Chebyshev UCL | 8.359 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 17.57 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.803 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.216 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0716 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.678 | k star (bias corrected MLE) | 0.67 |
| Theta hat (MLE) | 10.8 | Theta star (bias corrected MLE) | 10.92 |
| nu hat (MLE) | 245.4 | nu star (bias corrected) | 242.7 |
| MLE Mean (bias corrected) | 7.318 | MLE Sd (bias corrected) | 8.939 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.112 | nu hat (KM) | 100 |
| Approximate Chi Square Value (100.01, α) | 77.94 | Adjusted Chi Square Value (100.01, β) | 77.87 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 4.441 | 95% Gamma Adjusted KM-UCL (use when n<50) | 4.444 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 3.287 |
| Maximum | 113 | Median | 0.01 |
| SD | 10.56 | CV | 3.213 |
| k hat (MLE) | 0.223 | k star (bias corrected MLE) | 0.223 |
| Theta hat (MLE) | 14.75 | Theta star (bias corrected MLE) | 14.75 |
| nu hat (MLE) | 199.3 | nu star (bias corrected) | 199.3 |
| MLE Mean (bias corrected) | 3.287 | MLE Sd (bias corrected) | 6.962 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (199.28, α) | 167.6 | Adjusted Chi Square Value (199.28, β) | 167.5 |
| 95% Gamma Approximate UCL (use when n>=50) | 3.908 | 95% Gamma Adjusted UCL (use when n<50) | 3.91 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.124 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0659 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 3.308 | Mean in Log Scale | -0.41 |
| SD in Original Scale | 10.41 | SD in Log Scale | 1.731 |
| 95% t UCL (assumes normality of ROS data) | 4.12 | 95% Percentile Bootstrap UCL | 4.162 |
| 95% BCA Bootstrap UCL | 4.319 | 95% Bootstrap t UCL | 4.345 |
| 95% H-UCL (Log ROS) | 3.728 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 3.935 | Mean in Log Scale | 0.311 |
| SD in Original Scale | 10.34 | SD in Log Scale | 1.288 |
| 95% t UCL (Assumes normality) | 4.741 | 95% H-Stat UCL | 3.608 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 4.338

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (cobalt)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 87 |
| Number of Detects | 139 | Number of Non-Detects | 309 |
| Number of Distinct Detects | 80 | Number of Distinct Non-Detects | 10 |
| Minimum Detect | 0.4 | Minimum Non-Detect | 0.3 |
| Maximum Detect | 50.4 | Maximum Non-Detect | 50 |
| Variance Detects | 65.79 | Percent Non-Detects | 68.97% |
| Mean Detects | 5.736 | SD Detects | 8.111 |
| Median Detects | 2.3 | CV Detects | 1.414 |
| Skewness Detects | 2.653 | Kurtosis Detects | 8.292 |
| Mean of Logged Detects | 1.065 | SD of Logged Detects | 1.115 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.65 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.268 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0751 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 2.156 | Standard Error of Mean | 0.262 |
| SD | 5.318 | 95% KM (BCA) UCL | 2.585 |
| 95% KM (t) UCL | 2.588 | 95% KM (Percentile Bootstrap) UCL | 2.593 |
| 95% KM (z) UCL | 2.587 | 95% KM Bootstrap t UCL | 2.667 |
| 90% KM Chebyshev UCL | 2.942 | 95% KM Chebyshev UCL | 3.298 |
| 97.5% KM Chebyshev UCL | 3.792 | 99% KM Chebyshev UCL | 4.762 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 6.199 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.79 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.169 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0822 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.863 | k star (bias corrected MLE) | 0.849 |
| Theta hat (MLE) | 6.65 | Theta star (bias corrected MLE) | 6.758 |
| nu hat (MLE) | 239.8 | nu star (bias corrected) | 236 |
| MLE Mean (bias corrected) | 5.736 | MLE Sd (bias corrected) | 6.226 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.164 | nu hat (KM) | 147.3 |
| Approximate Chi Square Value (147.29, α) | 120.2 | Adjusted Chi Square Value (147.29, β) | 120.2 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.641 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.643 |

**Gamma ROS Statistics using Imputed  Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 1.932 |
| Maximum | 50.4 | Median | 0.01 |
| SD | 5.327 | CV | 2.758 |
| k hat (MLE) | 0.216 | k star (bias corrected MLE) | 0.216 |
| Theta hat (MLE) | 8.934 | Theta star (bias corrected MLE) | 8.932 |
| nu hat (MLE) | 193.8 | nu star (bias corrected) | 193.8 |
| MLE Mean (bias corrected) | 1.932 | MLE Sd (bias corrected) | 4.154 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (193.79, α) | 162.6 | Adjusted Chi Square Value (193.79, β) | 162.5 |
| 95% Gamma Approximate UCL (use when n>=50) | 2.303 | 95% Gamma Adjusted UCL (use when n<50) | 2.304 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0912 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0751 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 2.035 | Mean in Log Scale | -1.099 |
| SD in Original Scale | 5.242 | SD in Log Scale | 1.978 |
| 95% t UCL (assumes normality of ROS data) | 2.443 | 95% Percentile Bootstrap UCL | 2.447 |
| 95% BCA Bootstrap UCL | 2.505 | 95% Bootstrap t UCL | 2.498 |
| 95% H-UCL (Log ROS) | 3.129 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 4.173 | Mean in Log Scale | -0.0814 |
| SD in Original Scale | 8.229 | SD in Log Scale | 1.604 |
| 95% t UCL (Assumes normality) | 4.814 | 95% H-Stat UCL | 4.08 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 2.585

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (copper)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 113 |
| Number of Detects | 198 | Number of Non-Detects | 250 |
| Number of Distinct Detects | 108 | Number of Distinct Non-Detects | 11 |
| Minimum Detect | 1 | Minimum Non-Detect | 0.7 |
| Maximum Detect | 307 | Maximum Non-Detect | 10 |
| Variance Detects | 718.6 | Percent Non-Detects | 55.8% |
| Mean Detects | 11.23 | SD Detects | 26.81 |
| Median Detects | 4.9 | CV Detects | 2.388 |
| Skewness Detects | 7.815 | Kurtosis Detects | 77.67 |
| Mean of Logged Detects | 1.722 | SD of Logged Detects | 0.965 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.356 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.351 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.063 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 5.666 | Standard Error of Mean | 0.877 |
| SD | 18.48 | 95% KM (BCA) UCL | 7.327 |
| 95% KM (t) UCL | 7.111 | 95% KM (Percentile Bootstrap) UCL | 7.179 |
| 95% KM (z) UCL | 7.108 | 95% KM Bootstrap t UCL | 7.992 |
| 90% KM Chebyshev UCL | 8.296 | 95% KM Chebyshev UCL | 9.488 |
| 97.5% KM Chebyshev UCL | 11.14 | 99% KM Chebyshev UCL | 14.39 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 15.44 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.791 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.217 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0665 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.847 | k star (bias corrected MLE) | 0.837 |
| Theta hat (MLE) | 13.26 | Theta star (bias corrected MLE) | 13.41 |
| nu hat (MLE) | 335.3 | nu star (bias corrected) | 331.6 |
| MLE Mean (bias corrected) | 11.23 | MLE Sd (bias corrected) | 12.27 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.094 | nu hat (KM) | 84.23 |
| Approximate Chi Square Value (84.23, α) | 64.07 | Adjusted Chi Square Value (84.23, β) | 64.02 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 7.449 | 95% Gamma Adjusted KM-UCL (use when n<50) | 7.455 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 5.302 |
| Maximum | 307 | Median | 0.01 |
| SD | 18.68 | CV | 3.522 |
| k hat (MLE) | 0.224 | k star (bias corrected MLE) | 0.224 |
| Theta hat (MLE) | 23.72 | Theta star (bias corrected MLE) | 23.72 |
| nu hat (MLE) | 200.3 | nu star (bias corrected) | 200.3 |
| MLE Mean (bias corrected) | 5.302 | MLE Sd (bias corrected) | 11.21 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (200.30, α) | 168.6 | Adjusted Chi Square Value (200.30, β) | 168.5 |
| 95% Gamma Approximate UCL (use when n>=50) | 6.3 | 95% Gamma Adjusted UCL (use when n<50) | 6.304 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.122 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.063 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 5.61 | Mean in Log Scale | 0.541 |
| SD in Original Scale | 18.52 | SD in Log Scale | 1.452 |
| 95% t UCL (assumes normality of ROS data) | 7.052 | 95% Percentile Bootstrap UCL | 7.164 |
| 95% BCA Bootstrap UCL | 7.619 | 95% Bootstrap t UCL | 7.926 |
| 95% H-UCL (Log ROS) | 5.853 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 6.07 | Mean in Log Scale | 0.903 |
| SD in Original Scale | 18.43 | SD in Log Scale | 1.185 |
| 95% t UCL (Assumes normality) | 7.505 | 95% H-Stat UCL | 5.654 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 7.111 | 95% KM (% Bootstrap) UCL | 7.179 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (iron)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 449 | Number of Distinct Observations | 388 |
| Number of Detects | 420 | Number of Non-Detects | 29 |
| Number of Distinct Detects | 381 | Number of Distinct Non-Detects | 8 |
| Minimum Detect | 17.1 | Minimum Non-Detect | 7.4 |
| Maximum Detect | 69500 | Maximum Non-Detect | 186 |
| Variance Detects | 2.590E+8 | Percent Non-Detects | 6.459% |
| Mean Detects | 9738 | SD Detects | 16093 |
| Median Detects | 1540 | CV Detects | 1.653 |
| Skewness Detects | 1.923 | Kurtosis Detects | 2.771 |
| Mean of Logged Detects | 7.465 | SD of Logged Detects | 2.158 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.641 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.3 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0432 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 9111 | Standard Error of Mean | 743.1 |
| SD | 15728 | 95% KM (BCA) UCL | 10281 |
| 95% KM (t) UCL | 10336 | 95% KM (Percentile Bootstrap) UCL | 10361 |
| 95% KM (z) UCL | 10334 | 95% KM Bootstrap t UCL | 10465 |
| 90% KM Chebyshev UCL | 11341 | 95% KM Chebyshev UCL | 12350 |
| 97.5% KM Chebyshev UCL | 13752 | 99% KM Chebyshev UCL | 16505 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 11.47 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.851 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.151 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0475 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.385 | k star (bias corrected MLE) | 0.384 |
| Theta hat (MLE) | 25282 | Theta star (bias corrected MLE) | 25358 |
| nu hat (MLE) | 323.6 | nu star (bias corrected) | 322.6 |
| MLE Mean (bias corrected) | 9738 | MLE Sd (bias corrected) | 15714 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.336 | nu hat (KM) | 301.4 |
| Approximate Chi Square Value (301.37, α) | 262.2 | Adjusted Chi Square Value (301.37, β) | 262 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 10474 | 95% Gamma Adjusted KM-UCL (use when n<50) | 10479 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 9109 |
| Maximum | 69500 | Median | 1350 |
| SD | 15747 | CV | 1.729 |
| k hat (MLE) | 0.286 | k star (bias corrected MLE) | 0.285 |
| Theta hat (MLE) | 31869 | Theta star (bias corrected MLE) | 31917 |
| nu hat (MLE) | 256.7 | nu star (bias corrected) | 256.3 |
| MLE Mean (bias corrected) | 9109 | MLE Sd (bias corrected) | 17051 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (256.29, α) | 220.2 | Adjusted Chi Square Value (256.29, β) | 220.1 |
| 95% Gamma Approximate UCL (use when n>=50) | 10601 | 95% Gamma Adjusted UCL (use when n<50) | 10606 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0625 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0432 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 9112 | Mean in Log Scale | 7.189 |
| SD in Original Scale | 15745 | SD in Log Scale | 2.353 |
| 95% t UCL (assumes normality of ROS data) | 10337 | 95% Percentile Bootstrap UCL | 10285 |
| 95% BCA Bootstrap UCL | 10356 | 95% Bootstrap t UCL | 10392 |
| 95% H-UCL (Log ROS) | 31220 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 9112 | Mean in Log Scale | 7.194 |
| SD in Original Scale | 15745 | SD in Log Scale | 2.34 |
| 95% t UCL (Assumes normality) | 10336 | 95% H-Stat UCL | 30313 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

97.5% KM (Chebyshev) UCL 13752

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (lead)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 71 |
| Number of Detects | 129 | Number of Non-Detects | 319 |
| Number of Distinct Detects | 67 | Number of Distinct Non-Detects | 12 |
| Minimum Detect | 1 | Minimum Non-Detect | 0.94 |
| Maximum Detect | 53.6 | Maximum Non-Detect | 4.2 |
| Variance Detects | 72.89 | Percent Non-Detects | 71.21% |
| Mean Detects | 5.879 | SD Detects | 8.537 |
| Median Detects | 3.1 | CV Detects | 1.452 |
| Skewness Detects | 3.71 | Kurtosis Detects | 15.02 |
| Mean of Logged Detects | 1.307 | SD of Logged Detects | 0.835 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.523 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.308 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.078 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 2.449 | Standard Error of Mean | 0.241 |
| SD | 5.062 | 95% KM (BCA) UCL | 2.823 |
| 95% KM (t) UCL | 2.846 | 95% KM (Percentile Bootstrap) UCL | 2.861 |
| 95% KM (z) UCL | 2.845 | 95% KM Bootstrap t UCL | 2.976 |
| 90% KM Chebyshev UCL | 3.171 | 95% KM Chebyshev UCL | 3.498 |
| 97.5% KM Chebyshev UCL | 3.953 | 99% KM Chebyshev UCL | 4.845 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 8.269 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.778 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.176 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.084 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.217 | k star (bias corrected MLE) | 1.193 |
| Theta hat (MLE) | 4.833 | Theta star (bias corrected MLE) | 4.926 |
| nu hat (MLE) | 313.9 | nu star (bias corrected) | 307.9 |
| MLE Mean (bias corrected) | 5.879 | MLE Sd (bias corrected) | 5.382 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.234 | nu hat (KM) | 209.7 |
| Approximate Chi Square Value (209.67, α) | 177.2 | Adjusted Chi Square Value (209.67, β) | 177.1 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.898 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.9 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 1.707 |
| Maximum | 53.6 | Median | 0.01 |
| SD | 5.285 | CV | 3.097 |
| k hat (MLE) | 0.214 | k star (bias corrected MLE) | 0.214 |
| Theta hat (MLE) | 7.979 | Theta star (bias corrected MLE) | 7.977 |
| nu hat (MLE) | 191.7 | nu star (bias corrected) | 191.7 |
| MLE Mean (bias corrected) | 1.707 | MLE Sd (bias corrected) | 3.69 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (191.71, α) | 160.7 | Adjusted Chi Square Value (191.71, β) | 160.6 |
| 95% Gamma Approximate UCL (use when n>=50) | 2.036 | 95% Gamma Adjusted UCL (use when n<50) | 2.038 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0996 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.078 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 2.057 | Mean in Log Scale | -0.412 |
| SD in Original Scale | 5.19 | SD in Log Scale | 1.469 |
| 95% t UCL (assumes normality of ROS data) | 2.461 | 95% Percentile Bootstrap UCL | 2.503 |
| 95% BCA Bootstrap UCL | 2.55 | 95% Bootstrap t UCL | 2.595 |
| 95% H-UCL (Log ROS) | 2.321 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 2.334 | Mean in Log Scale | 0.274 |
| SD in Original Scale | 5.101 | SD in Log Scale | 0.828 |
| 95% t UCL (Assumes normality) | 2.731 | 95% H-Stat UCL | 2.003 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 2.846 | 95% KM (% Bootstrap) UCL | 2.861 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (manganese)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 450 | Number of Distinct Observations | 368 |
| Number of Detects | 406 | Number of Non-Detects | 44 |
| Number of Distinct Detects | 363 | Number of Distinct Non-Detects | 6 |
| Minimum Detect | 0.3 | Minimum Non-Detect | 0.12 |
| Maximum Detect | 16300 | Maximum Non-Detect | 15 |
| Variance Detects | 7125366 | Percent Non-Detects | 9.778% |
| Mean Detects | 1492 | SD Detects | 2669 |
| Median Detects | 276.5 | CV Detects | 1.789 |
| Skewness Detects | 2.581 | Kurtosis Detects | 6.759 |
| Mean of Logged Detects | 5.398 | SD of Logged Detects | 2.464 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.609 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.288 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.044 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 1347 | Standard Error of Mean | 121.3 |
| SD | 2571 | 95% KM (BCA) UCL | 1537 |
| 95% KM (t) UCL | 1547 | 95% KM (Percentile Bootstrap) UCL | 1557 |
| 95% KM (z) UCL | 1546 | 95% KM Bootstrap t UCL | 1556 |
| 90% KM Chebyshev UCL | 1711 | 95% KM Chebyshev UCL | 1876 |
| 97.5% KM Chebyshev UCL | 2104 | 99% KM Chebyshev UCL | 2554 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 4.426 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.859 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.0912 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0485 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.352 | k star (bias corrected MLE) | 0.351 |
| Theta hat (MLE) | 4242 | Theta star (bias corrected MLE) | 4254 |
| nu hat (MLE) | 285.7 | nu star (bias corrected) | 284.9 |
| MLE Mean (bias corrected) | 1492 | MLE Sd (bias corrected) | 2519 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.274 | nu hat (KM) | 247 |
| Approximate Chi Square Value (246.99, α) | 211.6 | Adjusted Chi Square Value (246.99, β) | 211.5 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 1572 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1573 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 1346 |
| Maximum | 16300 | Median | 198 |
| SD | 2574 | CV | 1.911 |
| k hat (MLE) | 0.254 | k star (bias corrected MLE) | 0.254 |
| Theta hat (MLE) | 5294 | Theta star (bias corrected MLE) | 5298 |
| nu hat (MLE) | 228.9 | nu star (bias corrected) | 228.7 |
| MLE Mean (bias corrected) | 1346 | MLE Sd (bias corrected) | 2671 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (228.71, α) | 194.7 | Adjusted Chi Square Value (228.71, β) | 194.6 |
| 95% Gamma Approximate UCL (use when n>=50) | 1582 | 95% Gamma Adjusted UCL (use when n<50) | 1582 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0653 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.044 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 1347 | Mean in Log Scale | 4.931 |
| SD in Original Scale | 2573 | SD in Log Scale | 2.772 |
| 95% t UCL (assumes normality of ROS data) | 1547 | 95% Percentile Bootstrap UCL | 1549 |
| 95% BCA Bootstrap UCL | 1553 | 95% Bootstrap t UCL | 1568 |
| 95% H-UCL (Log ROS) | 10916 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 1347 | Mean in Log Scale | 4.914 |
| SD in Original Scale | 2573 | SD in Log Scale | 2.83 |
| 95% t UCL (Assumes normality) | 1547 | 95% H-Stat UCL | 12864 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

97.5% KM (Chebyshev) UCL 2104

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (methyl tert butyl ether)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 455 | Number of Distinct Observations | 29 |
| Number of Detects | 27 | Number of Non-Detects | 428 |
| Number of Distinct Detects | 23 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.24 | Minimum Non-Detect | 0.14 |
| Maximum Detect | 171 | Maximum Non-Detect | 0.29 |
| Variance Detects | 1073 | Percent Non-Detects | 94.07% |
| Mean Detects | 7.146 | SD Detects | 32.76 |
| Median Detects | 0.41 | CV Detects | 4.585 |
| Skewness Detects | 5.189 | Kurtosis Detects | 26.95 |
| Mean of Logged Detects | -0.369 | SD of Logged Detects | 1.363 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.216 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.923 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.502 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.171 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.556 | Standard Error of Mean | 0.382 |
| SD | 8.004 | 95% KM (BCA) UCL | 1.313 |
| 95% KM (t) UCL | 1.186 | 95% KM (Percentile Bootstrap) UCL | 1.305 |
| 95% KM (z) UCL | 1.185 | 95% KM Bootstrap t UCL | 16.26 |
| 90% KM Chebyshev UCL | 1.703 | 95% KM Chebyshev UCL | 2.223 |
| 97.5% KM Chebyshev UCL | 2.944 | 99% KM Chebyshev UCL | 4.361 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 6.628 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.855 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.38 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.183 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.296 | k star (bias corrected MLE) | 0.288 |
| Theta hat (MLE) | 24.15 | Theta star (bias corrected MLE) | 24.84 |
| nu hat (MLE) | 15.98 | nu star (bias corrected) | 15.54 |
| MLE Mean (bias corrected) | 7.146 | MLE Sd (bias corrected) | 13.32 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.00482 | nu hat (KM) | 4.389 |
| Approximate Chi Square Value (4.39, α) | 0.881 | Adjusted Chi Square Value (4.39, β) | 0.876 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.769 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.784 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.433 |
| Maximum | 171 | Median | 0.01 |
| SD | 8.02 | CV | 18.5 |
| k hat (MLE) | 0.208 | k star (bias corrected MLE) | 0.208 |
| Theta hat (MLE) | 2.084 | Theta star (bias corrected MLE) | 2.084 |
| nu hat (MLE) | 189.2 | nu star (bias corrected) | 189.3 |
| MLE Mean (bias corrected) | 0.433 | MLE Sd (bias corrected) | 0.95 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (189.30, α) | 158.5 | Adjusted Chi Square Value (189.30, β) | 158.4 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.518 | 95% Gamma Adjusted UCL (use when n<50) | 0.518 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.676 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.923 | Detected Data Not Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.25 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.171 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.43 | Mean in Log Scale | -7.578 |
| SD in Original Scale | 8.02 | SD in Log Scale | 3.542 |
| 95% t UCL (assumes normality of ROS data) | 1.05 | 95% Percentile Bootstrap UCL | 1.182 |
| 95% BCA Bootstrap UCL | 1.928 | 95% Bootstrap t UCL | 15.7 |
| 95% H-UCL (Log ROS) | 0.606 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.525 | Mean in Log Scale | -2.139 |
| SD in Original Scale | 8.015 | SD in Log Scale | 0.589 |
| 95% t UCL (Assumes normality) | 1.145 | 95% H-Stat UCL | 0.147 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 1.313

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (naphthalene)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 438 | Number of Distinct Observations | 83 |
| Number of Detects | 57 | Number of Non-Detects | 381 |
| Number of Distinct Detects | 56 | Number of Distinct Non-Detects | 28 |
| Minimum Detect | 0.128 | Minimum Non-Detect | 0.014 |
| Maximum Detect | 9.1 | Maximum Non-Detect | 6.9 |
| Variance Detects | 3.985 | Percent Non-Detects | 86.99% |
| Mean Detects | 1.73 | SD Detects | 1.996 |
| Median Detects | 0.796 | CV Detects | 1.154 |
| Skewness Detects | 1.69 | Kurtosis Detects | 2.787 |
| Mean of Logged Detects | -0.12 | SD of Logged Detects | 1.217 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.774 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 2.251E-11 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.222 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.117 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.238 | Standard Error of Mean | 0.0444 |
| SD | 0.919 | 95% KM (BCA) UCL | 0.312 |
| 95% KM (t) UCL | 0.312 | 95% KM (Percentile Bootstrap) UCL | 0.316 |
| 95% KM (z) UCL | 0.311 | 95% KM Bootstrap t UCL | 0.331 |
| 90% KM Chebyshev UCL | 0.372 | 95% KM Chebyshev UCL | 0.432 |
| 97.5% KM Chebyshev UCL | 0.515 | 99% KM Chebyshev UCL | 0.68 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 1.297 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.786 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.125 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.122 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.877 | k star (bias corrected MLE) | 0.843 |
| Theta hat (MLE) | 1.972 | Theta star (bias corrected MLE) | 2.052 |
| nu hat (MLE) | 100 | nu star (bias corrected) | 96.09 |
| MLE Mean (bias corrected) | 1.73 | MLE Sd (bias corrected) | 1.884 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0673 | nu hat (KM) | 58.98 |
| Approximate Chi Square Value (58.98, α) | 42.32 | Adjusted Chi Square Value (58.98, β) | 42.27 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.332 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.333 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.234 |
| Maximum | 9.1 | Median | 0.01 |
| SD | 0.92 | CV | 3.934 |
| k hat (MLE) | 0.273 | k star (bias corrected MLE) | 0.272 |
| Theta hat (MLE) | 0.857 | Theta star (bias corrected MLE) | 0.859 |
| nu hat (MLE) | 238.9 | nu star (bias corrected) | 238.6 |
| MLE Mean (bias corrected) | 0.234 | MLE Sd (bias corrected) | 0.448 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (238.58, α) | 203.8 | Adjusted Chi Square Value (238.58, β) | 203.7 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.274 | 95% Gamma Adjusted UCL (use when n<50) | 0.274 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0857 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.117 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Approximate Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.246 | Mean in Log Scale | -4.478 |
| SD in Original Scale | 0.918 | SD in Log Scale | 2.549 |
| 95% t UCL (assumes normality of ROS data) | 0.318 | 95% Percentile Bootstrap UCL | 0.32 |
| 95% BCA Bootstrap UCL | 0.326 | 95% Bootstrap t UCL | 0.336 |
| 95% H-UCL (Log ROS) | 0.464 | | |

**UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -3.723 | 95% H-UCL (KM -Log) | 0.0845 |
| KM SD (logged) | 1.467 | 95% Critical H Value (KM-Log) | 2.515 |
| KM Standard Error of Mean (logged) | 0.071 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.255 | Mean in Log Scale | -3.916 |
| SD in Original Scale | 0.938 | SD in Log Scale | 1.676 |
| 95% t UCL (Assumes normality) | 0.329 | 95% H-Stat UCL | 0.101 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Approximate Lognormal Distributed at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 0.312

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (nickel)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 127 |
| Number of Detects | 257 | Number of Non-Detects | 191 |
| Number of Distinct Detects | 121 | Number of Distinct Non-Detects | 17 |
| Minimum Detect | 0.6 | Minimum Non-Detect | 0.41 |
| Maximum Detect | 104 | Maximum Non-Detect | 40.9 |
| Variance Detects | 145.5 | Percent Non-Detects | 42.63% |
| Mean Detects | 7.506 | SD Detects | 12.06 |
| Median Detects | 3.6 | CV Detects | 1.607 |
| Skewness Detects | 4.358 | Kurtosis Detects | 24.22 |
| Mean of Logged Detects | 1.401 | SD of Logged Detects | 1.016 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.539 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.283 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0553 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 4.89 | Standard Error of Mean | 0.461 |
| SD | 9.676 | 95% KM (BCA) UCL | 5.673 |
| 95% KM (t) UCL | 5.649 | 95% KM (Percentile Bootstrap) UCL | 5.703 |
| 95% KM (z) UCL | 5.648 | 95% KM Bootstrap t UCL | 5.854 |
| 90% KM Chebyshev UCL | 6.272 | 95% KM Chebyshev UCL | 6.898 |
| 97.5% KM Chebyshev UCL | 7.768 | 99% KM Chebyshev UCL | 9.475 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 10.48 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.787 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.157 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0589 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.946 | k star (bias corrected MLE) | 0.937 |
| Theta hat (MLE) | 7.935 | Theta star (bias corrected MLE) | 8.006 |
| nu hat (MLE) | 486.2 | nu star (bias corrected) | 481.9 |
| MLE Mean (bias corrected) | 7.506 | MLE Sd (bias corrected) | 7.752 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.255 | nu hat (KM) | 228.8 |
| Approximate Chi Square Value (228.81, α) | 194.8 | Adjusted Chi Square Value (228.81, β) | 194.7 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 5.743 | 95% Gamma Adjusted KM-UCL (use when n<50) | 5.746 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 4.736 |
| Maximum | 104 | Median | 1.8 |
| SD | 9.838 | CV | 2.077 |
| k hat (MLE) | 0.305 | k star (bias corrected MLE) | 0.304 |
| Theta hat (MLE) | 15.55 | Theta star (bias corrected MLE) | 15.57 |
| nu hat (MLE) | 273 | nu star (bias corrected) | 272.5 |
| MLE Mean (bias corrected) | 4.736 | MLE Sd (bias corrected) | 8.589 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (272.51, α) | 235.3 | Adjusted Chi Square Value (272.51, β) | 235.2 |
| 95% Gamma Approximate UCL (use when n>=50) | 5.486 | 95% Gamma Adjusted UCL (use when n<50) | 5.489 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0689 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0553 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 4.875 | Mean in Log Scale | 0.684 |
| SD in Original Scale | 9.69 | SD in Log Scale | 1.321 |
| 95% t UCL (assumes normality of ROS data) | 5.63 | 95% Percentile Bootstrap UCL | 5.669 |
| 95% BCA Bootstrap UCL | 5.727 | 95% Bootstrap t UCL | 5.78 |
| 95% H-UCL (Log ROS) | 5.5 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 5.419 | Mean in Log Scale | 0.95 |
| SD in Original Scale | 9.593 | SD in Log Scale | 1.214 |
| 95% t UCL (Assumes normality) | 6.166 | 95% H-Stat UCL | 6.162 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (Chebyshev) UCL 6.898

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (selenium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 53 |
| Number of Detects | 84 | Number of Non-Detects | 364 |
| Number of Distinct Detects | 46 | Number of Distinct Non-Detects | 10 |
| Minimum Detect | 1.6 | Minimum Non-Detect | 1.5 |
| Maximum Detect | 10.1 | Maximum Non-Detect | 10 |
| Variance Detects | 4.077 | Percent Non-Detects | 81.25% |
| Mean Detects | 4.372 | SD Detects | 2.019 |
| Median Detects | 3.9 | CV Detects | 0.462 |
| Skewness Detects | 0.849 | Kurtosis Detects | -0.0457 |
| Mean of Logged Detects | 1.374 | SD of Logged Detects | 0.453 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.909 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 1.7956E-6 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.125 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0967 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 2.131 | Standard Error of Mean | 0.0722 |
| SD | 1.445 | 95% KM (BCA) UCL | 2.256 |
| 95% KM (t) UCL | 2.25 | 95% KM (Percentile Bootstrap) UCL | 2.25 |
| 95% KM (z) UCL | 2.25 | 95% KM Bootstrap t UCL | 2.258 |
| 90% KM Chebyshev UCL | 2.348 | 95% KM Chebyshev UCL | 2.446 |
| 97.5% KM Chebyshev UCL | 2.582 | 99% KM Chebyshev UCL | 2.849 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 0.913 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.755 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.0983 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0977 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 5.089 | k star (bias corrected MLE) | 4.915 |
| Theta hat (MLE) | 0.859 | Theta star (bias corrected MLE) | 0.889 |
| nu hat (MLE) | 855 | nu star (bias corrected) | 825.8 |
| MLE Mean (bias corrected) | 4.372 | MLE Sd (bias corrected) | 1.972 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 2.175 | nu hat (KM) | 1949 |
| Approximate Chi Square Value (N/A, α) | 1848 | Adjusted Chi Square Value (N/A, β) | 1847 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.248 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.249 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 1.215 |
| Maximum | 10.1 | Median | 0.01 |
| SD | 1.912 | CV | 1.574 |
| k hat (MLE) | 0.299 | k star (bias corrected MLE) | 0.299 |
| Theta hat (MLE) | 4.06 | Theta star (bias corrected MLE) | 4.067 |
| nu hat (MLE) | 268 | nu star (bias corrected) | 267.6 |
| MLE Mean (bias corrected) | 1.215 | MLE Sd (bias corrected) | 2.223 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (267.58, α) | 230.7 | Adjusted Chi Square Value (267.58, β) | 230.6 |
| 95% Gamma Approximate UCL (use when n>=50) | 1.409 | 95% Gamma Adjusted UCL (use when n<50) | 1.41 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.0857 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0967 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Approximate Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 1.746 | Mean in Log Scale | 0.205 |
| SD in Original Scale | 1.661 | SD in Log Scale | 0.838 |
| 95% t UCL (assumes normality of ROS data) | 1.875 | 95% Percentile Bootstrap UCL | 1.881 |
| 95% BCA Bootstrap UCL | 1.878 | 95% Bootstrap t UCL | 1.884 |
| 95% H-UCL (Log ROS) | 1.885 | | |

**UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed**

| | | | |
|---|---|---|---|
| KM Mean (logged) | 0.629 | 95% H-UCL (KM -Log) | 2.142 |
| KM SD (logged) | 0.439 | 95% Critical H Value (KM-Log) | 1.758 |
| KM Standard Error of Mean (logged) | 0.0228 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 2.029 | Mean in Log Scale | 0.474 |
| SD in Original Scale | 1.652 | SD in Log Scale | 0.641 |
| 95% t UCL (Assumes normality) | 2.158 | 95% H-Stat UCL | 2.089 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Approximate Lognormal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 2.25 | 95% KM (% Bootstrap) UCL | 2.25 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (silver)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 449 | Number of Distinct Observations | 46 |
| Number of Detects | 94 | Number of Non-Detects | 355 |
| Number of Distinct Detects | 42 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.6 | Minimum Non-Detect | 0.53 |
| Maximum Detect | 10.2 | Maximum Non-Detect | 10 |
| Variance Detects | 3.11 | Percent Non-Detects | 79.06% |
| Mean Detects | 2.414 | SD Detects | 1.763 |
| Median Detects | 1.8 | CV Detects | 0.73 |
| Skewness Detects | 1.908 | Kurtosis Detects | 4.085 |
| Mean of Logged Detects | 0.678 | SD of Logged Detects | 0.617 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.794 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.22 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0914 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.951 | Standard Error of Mean | 0.0537 |
| SD | 1.114 | 95% KM (BCA) UCL | 1.04 |
| 95% KM (t) UCL | 1.039 | 95% KM (Percentile Bootstrap) UCL | 1.045 |
| 95% KM (z) UCL | 1.039 | 95% KM Bootstrap t UCL | 1.052 |
| 90% KM Chebyshev UCL | 1.112 | 95% KM Chebyshev UCL | 1.185 |
| 97.5% KM Chebyshev UCL | 1.286 | 99% KM Chebyshev UCL | 1.485 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 2.219 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.761 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.153 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0932 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 2.608 | k star (bias corrected MLE) | 2.532 |
| Theta hat (MLE) | 0.926 | Theta star (bias corrected MLE) | 0.953 |
| nu hat (MLE) | 490.4 | nu star (bias corrected) | 476 |
| MLE Mean (bias corrected) | 2.414 | MLE Sd (bias corrected) | 1.517 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.729 | nu hat (KM) | 654.3 |
| Approximate Chi Square Value (654.33, α) | 596 | Adjusted Chi Square Value (654.33, β) | 595.8 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 1.044 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1.044 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.543 |
| Maximum | 10.2 | Median | 0.01 |
| SD | 1.264 | CV | 2.325 |
| k hat (MLE) | 0.265 | k star (bias corrected MLE) | 0.265 |
| Theta hat (MLE) | 2.048 | Theta star (bias corrected MLE) | 2.05 |
| nu hat (MLE) | 238.3 | nu star (bias corrected) | 238.1 |
| MLE Mean (bias corrected) | 0.543 | MLE Sd (bias corrected) | 1.055 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (238.07, α) | 203.4 | Adjusted Chi Square Value (238.07, β) | 203.3 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.636 | 95% Gamma Adjusted UCL (use when n<50) | 0.637 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.107 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0914 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.766 | Mean in Log Scale | -1.02 |
| SD in Original Scale | 1.192 | SD in Log Scale | 1.233 |
| 95% t UCL (assumes normality of ROS data) | 0.859 | 95% Percentile Bootstrap UCL | 0.86 |
| 95% BCA Bootstrap UCL | 0.87 | 95% Bootstrap t UCL | 0.874 |
| 95% H-UCL (Log ROS) | 0.881 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.977 | Mean in Log Scale | -0.419 |
| SD in Original Scale | 1.268 | SD in Log Scale | 0.756 |
| 95% t UCL (Assumes normality) | 1.075 | 95% H-Stat UCL | 0.938 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 1.039 | 95% KM (% Bootstrap) UCL | 1.045 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (toluene)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 455 | Number of Distinct Observations | 67 |
| Number of Detects | 69 | Number of Non-Detects | 386 |
| Number of Distinct Detects | 62 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.16 | Minimum Non-Detect | 0.15 |
| Maximum Detect | 198 | Maximum Non-Detect | 45 |
| Variance Detects | 1191 | Percent Non-Detects | 84.84% |
| Mean Detects | 17.03 | SD Detects | 34.51 |
| Median Detects | 0.91 | CV Detects | 2.026 |
| Skewness Detects | 3.222 | Kurtosis Detects | 12.43 |
| Mean of Logged Detects | 0.86 | SD of Logged Detects | 2.088 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.566 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.312 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.107 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 2.714 | Standard Error of Mean | 0.692 |
| SD | 14.65 | 95% KM (BCA) UCL | 3.873 |
| 95% KM (t) UCL | 3.854 | 95% KM (Percentile Bootstrap) UCL | 3.922 |
| 95% KM (z) UCL | 3.852 | 95% KM Bootstrap t UCL | 4.48 |
| 90% KM Chebyshev UCL | 4.79 | 95% KM Chebyshev UCL | 5.73 |
| 97.5% KM Chebyshev UCL | 7.036 | 99% KM Chebyshev UCL | 9.6 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 5.397 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.855 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.258 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.116 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.342 | k star (bias corrected MLE) | 0.337 |
| Theta hat (MLE) | 49.84 | Theta star (bias corrected MLE) | 50.61 |
| nu hat (MLE) | 47.16 | nu star (bias corrected) | 46.44 |
| MLE Mean (bias corrected) | 17.03 | MLE Sd (bias corrected) | 29.36 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0343 | nu hat (KM) | 31.21 |
| Approximate Chi Square Value (31.21, α) | 19.45 | Adjusted Chi Square Value (31.21, β) | 19.42 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 4.355 | 95% Gamma Adjusted KM-UCL (use when n<50) | 4.362 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 2.592 |
| Maximum | 198 | Median | 0.01 |
| SD | 14.69 | CV | 5.668 |
| k hat (MLE) | 0.161 | k star (bias corrected MLE) | 0.161 |
| Theta hat (MLE) | 16.11 | Theta star (bias corrected MLE) | 16.07 |
| nu hat (MLE) | 146.4 | nu star (bias corrected) | 146.8 |
| MLE Mean (bias corrected) | 2.592 | MLE Sd (bias corrected) | 6.453 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (146.76, α) | 119.8 | Adjusted Chi Square Value (146.76, β) | 119.7 |
| 95% Gamma Approximate UCL (use when n>=50) | 3.176 | 95% Gamma Adjusted UCL (use when n<50) | 3.178 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.196 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.107 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 2.596 | Mean in Log Scale | -6.239 |
| SD in Original Scale | 14.69 | SD in Log Scale | 4.524 |
| 95% t UCL (assumes normality of ROS data) | 3.731 | 95% Percentile Bootstrap UCL | 3.947 |
| 95% BCA Bootstrap UCL | 4.141 | 95% Bootstrap t UCL | 4.243 |
| 95% H-UCL (Log ROS) | 195.7 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 2.74 | Mean in Log Scale | -1.666 |
| SD in Original Scale | 14.7 | SD in Log Scale | 1.402 |
| 95% t UCL (Assumes normality) | 3.876 | 95% H-Stat UCL | 0.594 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

97.5% KM (Chebyshev) UCL 7.036

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (trichloroethene)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 910 | Number of Distinct Observations | 11 |
| Number of Detects | 10 | Number of Non-Detects | 900 |
| Number of Distinct Detects | 5 | Number of Distinct Non-Detects | 6 |
| Minimum Detect | 0.7 | Minimum Non-Detect | 0.18 |
| Maximum Detect | 13.7 | Maximum Non-Detect | 0.33 |
| Variance Detects | 28.09 | Percent Non-Detects | 98.9% |
| Mean Detects | 3.69 | SD Detects | 5.3 |
| Median Detects | 1 | CV Detects | 1.436 |
| Skewness Detects | 1.739 | Kurtosis Detects | 1.322 |
| Mean of Logged Detects | 0.59 | SD of Logged Detects | 1.134 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.582 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.418 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.28 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 0.219 | Standard Error of Mean | 0.0224 |
| SD | 0.642 | 95% KM (BCA) UCL | 0.263 |
| 95% KM (t) UCL | 0.255 | 95% KM (Percentile Bootstrap) UCL | 0.257 |
| 95% KM (z) UCL | 0.255 | 95% KM Bootstrap t UCL | 0.405 |
| 90% KM Chebyshev UCL | 0.286 | 95% KM Chebyshev UCL | 0.316 |
| 97.5% KM Chebyshev UCL | 0.359 | 99% KM Chebyshev UCL | 0.442 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 1.522 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.754 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.334 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.275 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.826 | k star (bias corrected MLE) | 0.645 |
| Theta hat (MLE) | 4.466 | Theta star (bias corrected MLE) | 5.721 |
| nu hat (MLE) | 16.52 | nu star (bias corrected) | 12.9 |
| MLE Mean (bias corrected) | 3.69 | MLE Sd (bias corrected) | 4.595 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.116 | nu hat (KM) | 211.2 |
| Approximate Chi Square Value (211.18, α) | 178.5 | Adjusted Chi Square Value (211.18, β) | 178.5 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.259 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.259 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.0504 |
| Maximum | 13.7 | Median | 0.01 |
| SD | 0.652 | CV | 12.93 |
| k hat (MLE) | 0.418 | k star (bias corrected MLE) | 0.418 |
| Theta hat (MLE) | 0.121 | Theta star (bias corrected MLE) | 0.121 |
| nu hat (MLE) | 761.6 | nu star (bias corrected) | 760.4 |
| MLE Mean (bias corrected) | 0.0504 | MLE Sd (bias corrected) | 0.078 |
| | | Adjusted Level of Significance (β) | 0.0497 |
| Approximate Chi Square Value (760.45, α) | 697.5 | Adjusted Chi Square Value (760.45, β) | 697.4 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.055 | 95% Gamma Adjusted UCL (use when n<50) | 0.055 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.753 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.299 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.28 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.0448 | Mean in Log Scale | -10.78 |
| SD in Original Scale | 0.653 | SD in Log Scale | 4.281 |
| 95% t UCL (assumes normality of ROS data) | 0.0805 | 95% Percentile Bootstrap UCL | 0.0858 |
| 95% BCA Bootstrap UCL | 0.107 | 95% Bootstrap t UCL | 0.231 |
| 95% H-UCL (Log ROS) | 0.446 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.156 | Mean in Log Scale | -2.131 |
| SD in Original Scale | 0.646 | SD in Log Scale | 0.352 |
| 95% t UCL (Assumes normality) | 0.191 | 95% H-Stat UCL | 0.129 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 0.263

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (vanadium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 93 |
| Number of Detects | 209 | Number of Non-Detects | 239 |
| Number of Distinct Detects | 87 | Number of Distinct Non-Detects | 8 |
| Minimum Detect | 0.5 | Minimum Non-Detect | 0.43 |
| Maximum Detect | 77.8 | Maximum Non-Detect | 50 |
| Variance Detects | 79 | Percent Non-Detects | 53.35% |
| Mean Detects | 5.17 | SD Detects | 8.888 |
| Median Detects | 2.4 | CV Detects | 1.719 |
| Skewness Detects | 4.518 | Kurtosis Detects | 26.16 |
| Mean of Logged Detects | 0.998 | SD of Logged Detects | 1.024 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.51 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.3 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0613 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 2.893 | Standard Error of Mean | 0.331 |
| SD | 6.707 | 95% KM (BCA) UCL | 3.414 |
| 95% KM (t) UCL | 3.437 | 95% KM (Percentile Bootstrap) UCL | 3.444 |
| 95% KM (z) UCL | 3.436 | 95% KM Bootstrap t UCL | 3.601 |
| 90% KM Chebyshev UCL | 3.884 | 95% KM Chebyshev UCL | 4.333 |
| 97.5% KM Chebyshev UCL | 4.957 | 99% KM Chebyshev UCL | 6.181 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 9.645 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.789 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.167 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0647 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.906 | k star (bias corrected MLE) | 0.896 |
| Theta hat (MLE) | 5.709 | Theta star (bias corrected MLE) | 5.772 |
| nu hat (MLE) | 378.5 | nu star (bias corrected) | 374.4 |
| MLE Mean (bias corrected) | 5.17 | MLE Sd (bias corrected) | 5.463 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.186 | nu hat (KM) | 166.7 |
| Approximate Chi Square Value (166.69, α) | 137.8 | Adjusted Chi Square Value (166.69, β) | 137.8 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 3.498 | 95% Gamma Adjusted KM-UCL (use when n<50) | 3.5 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 2.68 |
| Maximum | 77.8 | Median | 0.5 |
| SD | 6.73 | CV | 2.512 |
| k hat (MLE) | 0.257 | k star (bias corrected MLE) | 0.257 |
| Theta hat (MLE) | 10.42 | Theta star (bias corrected MLE) | 10.43 |
| nu hat (MLE) | 230.3 | nu star (bias corrected) | 230.1 |
| MLE Mean (bias corrected) | 2.68 | MLE Sd (bias corrected) | 5.287 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (230.11, α) | 196 | Adjusted Chi Square Value (230.11, β) | 195.9 |
| 95% Gamma Approximate UCL (use when n>=50) | 3.146 | 95% Gamma Adjusted UCL (use when n<50) | 3.148 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.073 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0613 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 2.767 | Mean in Log Scale | -0.228 |
| SD in Original Scale | 6.603 | SD in Log Scale | 1.595 |
| 95% t UCL (assumes normality of ROS data) | 3.281 | 95% Percentile Bootstrap UCL | 3.308 |
| 95% BCA Bootstrap UCL | 3.4 | 95% Bootstrap t UCL | 3.41 |
| 95% H-UCL (Log ROS) | 3.464 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 5.133 | Mean in Log Scale | 0.334 |
| SD in Original Scale | 9.34 | SD in Log Scale | 1.564 |
| 95% t UCL (Assumes normality) | 5.86 | 95% H-Stat UCL | 5.751 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (BCA) UCL 3.414

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (xylenes)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 455 | Number of Distinct Observations | 44 |
| Number of Detects | 42 | Number of Non-Detects | 413 |
| Number of Distinct Detects | 40 | Number of Distinct Non-Detects | 6 |
| Minimum Detect | 0.22 | Minimum Non-Detect | 0.17 |
| Maximum Detect | 81.8 | Maximum Non-Detect | 0.39 |
| Variance Detects | 429.9 | Percent Non-Detects | 90.77% |
| Mean Detects | 13.21 | SD Detects | 20.73 |
| Median Detects | 1.4 | CV Detects | 1.57 |
| Skewness Detects | 1.731 | Kurtosis Detects | 2.257 |
| Mean of Logged Detects | 1.024 | SD of Logged Detects | 1.907 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.659 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.942 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.313 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.137 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 1.374 | Standard Error of Mean | 0.345 |
| SD | 7.278 | 95% KM (BCA) UCL | 2.04 |
| 95% KM (t) UCL | 1.943 | 95% KM (Percentile Bootstrap) UCL | 1.988 |
| 95% KM (z) UCL | 1.942 | 95% KM Bootstrap t UCL | 2.154 |
| 90% KM Chebyshev UCL | 2.41 | 95% KM Chebyshev UCL | 2.879 |
| 97.5% KM Chebyshev UCL | 3.531 | 99% KM Chebyshev UCL | 4.81 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 2.725 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.832 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.214 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.146 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.42 | k star (bias corrected MLE) | 0.405 |
| Theta hat (MLE) | 31.48 | Theta star (bias corrected MLE) | 32.57 |
| nu hat (MLE) | 35.24 | nu star (bias corrected) | 34.06 |
| MLE Mean (bias corrected) | 13.21 | MLE Sd (bias corrected) | 20.74 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0356 | nu hat (KM) | 32.43 |
| Approximate Chi Square Value (32.43, α) | 20.41 | Adjusted Chi Square Value (32.43, β) | 20.38 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 2.183 | 95% Gamma Adjusted KM-UCL (use when n<50) | 2.186 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 1.228 |
| Maximum | 81.8 | Median | 0.01 |
| SD | 7.311 | CV | 5.953 |
| k hat (MLE) | 0.175 | k star (bias corrected MLE) | 0.175 |
| Theta hat (MLE) | 7.016 | Theta star (bias corrected MLE) | 7.003 |
| nu hat (MLE) | 159.3 | nu star (bias corrected) | 159.6 |
| MLE Mean (bias corrected) | 1.228 | MLE Sd (bias corrected) | 2.933 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (159.58, α) | 131.4 | Adjusted Chi Square Value (159.58, β) | 131.3 |
| 95% Gamma Approximate UCL (use when n>=50) | 1.492 | 95% Gamma Adjusted UCL (use when n<50) | 1.493 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.822 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.942 | Detected Data Not Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.166 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.137 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 1.231 | Mean in Log Scale | -7.578 |
| SD in Original Scale | 7.31 | SD in Log Scale | 4.714 |
| 95% t UCL (assumes normality of ROS data) | 1.796 | 95% Percentile Bootstrap UCL | 1.823 |
| 95% BCA Bootstrap UCL | 1.967 | 95% Bootstrap t UCL | 1.994 |
| 95% H-UCL (Log ROS) | 137.6 | | |

**DL/2 Statistics**

| | | | |
|---|---|---|---|
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 1.332 | Mean in Log Scale | -1.832 |
| SD in Original Scale | 7.293 | SD in Log Scale | 1.109 |
| 95% t UCL (Assumes normality) | 1.896 | 95% H-Stat UCL | 0.332 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

95% KM (Chebyshev) UCL 2.879

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Appendix A**
**ProUCL Output**

**Site-Wide Groundwater BHHRA**
**Ringwood Mines/Landfill Superfund Site**
**Ringwood, New Jersey**

**UCL Statistics for Data Sets with Non-Detects**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 11/14/2014 11:23:21 AM |
| From File | Book1.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**Result (zinc)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 448 | Number of Distinct Observations | 239 |
| Number of Detects | 271 | Number of Non-Detects | 177 |
| Number of Distinct Detects | 230 | Number of Distinct Non-Detects | 17 |
| Minimum Detect | 1.9 | Minimum Non-Detect | 1.4 |
| Maximum Detect | 10700 | Maximum Non-Detect | 30 |
| Variance Detects | 2357471 | Percent Non-Detects | 39.51% |
| Mean Detects | 602.7 | SD Detects | 1535 |
| Median Detects | 26.6 | CV Detects | 2.548 |
| Skewness Detects | 4.273 | Kurtosis Detects | 21.04 |
| Mean of Logged Detects | 4.052 | SD of Logged Detects | 2.238 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.446 | **Normal GOF Test on Detected Observations Only** |
| 5% Shapiro Wilk P Value | 0 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.348 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0538 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| Mean | 365.9 | Standard Error of Mean | 58.1 |
| SD | 1227 | 95% KM (BCA) UCL | 463.7 |
| 95% KM (t) UCL | 461.7 | 95% KM (Percentile Bootstrap) UCL | 459.1 |
| 95% KM (z) UCL | 461.5 | 95% KM Bootstrap t UCL | 488.8 |
| 90% KM Chebyshev UCL | 540.2 | 95% KM Chebyshev UCL | 619.2 |
| 97.5% KM Chebyshev UCL | 728.8 | 99% KM Chebyshev UCL | 944 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 19.45 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.873 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.208 | **Kolmogrov-Smirnoff GOF** |
| 5% K-S Critical Value | 0.0603 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.294 | k star (bias corrected MLE) | 0.294 |
| Theta hat (MLE) | 2047 | Theta star (bias corrected MLE) | 2053 |
| nu hat (MLE) | 159.6 | nu star (bias corrected) | 159.1 |
| MLE Mean (bias corrected) | 602.7 | MLE Sd (bias corrected) | 1112 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| k hat (KM) | 0.0889 | nu hat (KM) | 79.64 |
| Approximate Chi Square Value (79.64, α) | 60.08 | Adjusted Chi Square Value (79.64, β) | 60.02 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 485.1 | 95% Gamma Adjusted KM-UCL (use when n<50) | 485.5 |

Gamma (KM) may not be used when k hat (KM) is < 0.1

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 364.6 |
| Maximum | 10700 | Median | 7.05 |
| SD | 1229 | CV | 3.372 |
| k hat (MLE) | 0.146 | k star (bias corrected MLE) | 0.147 |
| Theta hat (MLE) | 2490 | Theta star (bias corrected MLE) | 2481 |
| nu hat (MLE) | 131.2 | nu star (bias corrected) | 131.7 |
| MLE Mean (bias corrected) | 364.6 | MLE Sd (bias corrected) | 951 |
| | | Adjusted Level of Significance (β) | 0.0495 |
| Approximate Chi Square Value (131.66, α) | 106.1 | Adjusted Chi Square Value (131.66, β) | 106.1 |
| 95% Gamma Approximate UCL (use when n>=50) | 452.2 | 95% Gamma Adjusted UCL (use when n<50) | 452.5 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Lilliefors Test Statistic | 0.144 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.0538 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data Not Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 365.7 | Mean in Log Scale | 2.3 |
| SD in Original Scale | 1229 | SD in Log Scale | 3.01 |
| 95% t UCL (assumes normality of ROS data) | 461.4 | 95% Percentile Bootstrap UCL | 462 |
| 95% BCA Bootstrap UCL | 482.1 | 95% Bootstrap t UCL | 486.4 |
| 95% H-UCL (Log ROS) | 1685 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 366.6 | Mean in Log Scale | 2.974 |
| SD in Original Scale | 1229 | SD in Log Scale | 2.259 |
| 95% t UCL (Assumes normality) | 462.3 | 95% H-Stat UCL | 360.4 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution at 5% Significance Level**

**Suggested UCL to Use**

97.5% KM (Chebyshev) UCL 728.8

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

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**Appendix B**

Shower Model Calculations

**Appendix B**
**Shower Model Calculations (Hypothetical Future Adult Resident)**
**Central Tendency Exposure**
**Ringwood Mines/Landfill Superfund Site**

| |
|---|
| Scenario Timeframe : Future |
| Medium : Groundwater |
| Exposure Medium : Groundwater |

| Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Model Equations |
|---|---|---|---|---|---|
| T | Temperature | 305 | K | Sanders 2002 (1) | |
| $F_w$ | Shower Water Flow Rate | 500 | L/hour | Schaum et al. 1994 (2) | Concentration in Air ($C_A$) = $((C_{amax}/2)\ t_1 + C_{amax} t_2)/(t_1+t_2)$ |
| $t_1$ | Time Spent Showering | 0.33 | hour | USEPA 2011 (3),(4) | $C_{amax} = C_W\ f\ F_W\ t_1 / V_a$ |
| $t_2$ | Time Spent in Bathroom after Showering | 0.13 | hour | USEPA 2011 (3),(4) | $f_i = f_j\ (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_j / (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_i$ |
| $V_a$ | Bathroom Air Volume | 16 | $m^3$ | Schaum et al. 1994 (5) | |
| R | Gas Constant | 8.21E-05 | atm-$m^3$/mol-K | Schaum et al. 1994 | |

| **CAS Number** | **Chemical of Potential Concern** | **Exposure Point Concentration in Groundwater $C_w$ (µg/L)** | **Henry's Law Constant (6) H (atm-$m^3$/mol)** | **Molecular Weight (6) MW (g/mol)** | **Diffusivity in Air (6) $D_a$ ($m^2$/sec)** | **Diffusivity in Water (6) $D_w$ ($m^2$/sec)** | **Mass-Transfer Coefficient K (cm/hr)** | **Fraction Volatilized (7) *f* (unitless)** | **Maximum Concentration in Air $C_{a, max}$ (µg/$m^3$)** | **Exposure Point Concentration in Air $C_a$ (µg/$m^3$)** |
|---|---|---|---|---|---|---|---|---|---|---|
| 10043-92-2 | Radon | NA | 9.21E-02 | 2.22E+02 | 2.00E-05 | 1.40E-09 | 2.00E+06 | 0.63 | NA | NA |
| 75-34-3 | 1,1-Dichloroethane | 8.3E-01 | 5.62E-03 | 9.90E+01 | 8.36E-06 | 1.06E-09 | 2.42E+06 | 0.52 | 4.47E+00 | 2.86E+00 |
| 71-43-2 | Benzene | 1.5E+00 | 5.55E-03 | 7.81E+01 | 8.95E-06 | 1.03E-09 | 2.46E+06 | 0.51 | 7.88E+00 | 5.06E+00 |
| 1634-04-4 | Methyl tert butyl ether | 1.3E+00 | 5.87E-04 | 8.82E+01 | 7.53E-06 | 8.59E-10 | 2.88E+06 | 0.44 | 5.92E+00 | 3.80E+00 |
| 91-20-3 | Naphthalene | 3.1E-01 | 4.40E-04 | 1.28E+02 | 6.05E-06 | 8.38E-10 | 2.98E+06 | 0.42 | 1.36E+00 | 8.70E-01 |
| 108-88-3 | Toluene | 5.7E+00 | 6.64E-03 | 9.21E+01 | 7.78E-06 | 9.20E-10 | 2.65E+06 | 0.47 | 2.81E+01 | 1.80E+01 |
| 79-01-6 | Trichloroethene | 2.6E-01 | 9.85E-03 | 1.31E+02 | 6.87E-06 | 1.02E-09 | 2.47E+06 | 0.51 | 1.38E+00 | 8.85E-01 |
| 1330-20-7 | Xylenes | 2.9E+00 | 5.18E-03 | 1.06E+02 | 8.47E-06 | 9.90E-10 | 2.53E+06 | 0.50 | 1.48E+01 | 9.48E+00 |

Notes:

1. Average of the temperatures (21-46 degrees Celsius) reported in shower model studies from the literature (Keating et al. 1997; Giardino and Andelman 1996; Jo et al. 1990; and Moya et al. 1999) as summarized by Sanders (2002).
2. Low end of default range of estimates (500 to 1000 L/hour).
3. See Table 4.1.CT.
4. The mean for ages 16 - <21 from Table 16-28 in USEPA (2011).
5. Assumes bathroom dimensions of 7 feet by 10 feet by 8 feet, which approximates a bathroom containing a sink, toilet, and shower stall.
6. Chemical parameter values for constituents of potential concern obtained from the USEPA (2012) Regional Screening Levels (RSLs) tables. Chemical parameter values for radon obtained from McKone (1987).
7. Fraction volatilized (*f*) values were estimated using the reported *f* for radon (63%) during showers in Pritchard and Gesell (1981) as cited by Andelman (1990).

References:


Andelman, J.B. 1990. Total exposure to volatile organic compounds in potable water. Significance and Treatment of Volatile Organic Compounds in Water Supplies. N.M. Ram, R.F. Christman and K.P. Cantor, eds. Lewis Publishers, Chelsea, Michigan, pp. 485-504.

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**Appendix B**
**Shower Model Calculations (Hypothetical Future Adult Resident)**
**Reasonable Maximum Exposure**
**Ringwood Mines/Landfill Superfund Site**

| |
|---|
| Scenario Timeframe : Future |
| Medium : Groundwater |
| Exposure Medium : Groundwater |

| Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Model Equations |
|---|---|---|---|---|---|
| T | Temperature | 305 | K | Sanders 2002 (1) | |
| $F_w$ | Shower Water Flow Rate | 750 | L/hour | Schaum et al. 1994 (2) | Concentration in Air ($C_A$) = $((C_{amax}/2)\ t_1 + C_{amax}t_2)/(t_1+t_2)$ |
| $t_1$ | Time Spent Showering | 0.67 | hour | USEPA 2011 (3),(4) | $C_{amax} = C_W\, f\ F_W\, t_1 / V_a$ |
| $t_2$ | Time Spent in Bathroom after Showering | 0.25 | hour | USEPA 2011 (3),(4) | $f_i = f_j\ (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_j / (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_i$ |
| $V_a$ | Bathroom Air Volume | 16 | $m^3$ | Schaum et al. 1994 (5) | |
| R | Gas Constant | 8.21E-05 | atm-$m^3$/mol-K | Schaum et al. 1994 | |

| CAS Number | Chemical of Potential Concern | Exposure Point Concentration in Groundwater $C_w$ (µg/L) | Henry's Law Constant (6) H (atm-$m^3$/mol) | Molecular Weight (6) MW (g/mol) | Diffusivity in Air (6) $D_a$ ($m^2$/sec) | Diffusivity in Water (6) $D_w$ ($m^2$/sec) | Mass-Transfer Coefficient K (cm/hr) | Fraction Volatilized (7) $f$ (unitless) | Maximum Concentration in Air $C_{a,\,max}$ (µg/$m^3$) | Exposure Point Concentration in Air $C_a$ (µg/$m^3$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10043-92-2 | Radon | NA | 9.21E-02 | 2.22E+02 | 2.00E-05 | 1.40E-09 | 2.00E+06 | 0.63 | NA | NA |
| 75-34-3 | 1,1-Dichloroethane | 8.3E-01 | 5.62E-03 | 9.90E+01 | 8.36E-06 | 1.06E-09 | 2.42E+06 | 0.52 | 1.36E+01 | 8.65E+00 |
| 71-43-2 | Benzene | 1.5E+00 | 5.55E-03 | 7.81E+01 | 8.95E-06 | 1.03E-09 | 2.46E+06 | 0.51 | 2.40E+01 | 1.53E+01 |
| 1634-04-4 | Methyl tert butyl ether | 1.3E+00 | 5.87E-04 | 8.82E+01 | 7.53E-06 | 8.59E-10 | 2.88E+06 | 0.44 | 1.80E+01 | 1.15E+01 |
| 91-20-3 | Naphthalene | 3.1E-01 | 4.40E-04 | 1.28E+02 | 6.05E-06 | 8.38E-10 | 2.98E+06 | 0.42 | 4.13E+00 | 2.63E+00 |
| 108-88-3 | Toluene | 5.7E+00 | 6.64E-03 | 9.21E+01 | 7.78E-06 | 9.20E-10 | 2.65E+06 | 0.47 | 8.54E+01 | 5.43E+01 |
| 79-01-6 | Trichloroethene | 2.6E-01 | 9.85E-03 | 1.31E+02 | 6.87E-06 | 1.02E-09 | 2.47E+06 | 0.51 | 4.20E+00 | 2.67E+00 |
| 1330-20-7 | Xylenes | 2.9E+00 | 5.18E-03 | 1.06E+02 | 8.47E-06 | 9.90E-10 | 2.53E+06 | 0.50 | 4.50E+01 | 2.86E+01 |

Notes:

1. Average of the temperatures (21-46 degrees Celsius) reported in shower model studies from the literature (Keating et al. 1997; Giardino and Andelman 1996; Jo et al. 1990; and Moya et al. 1999) as summarized by Sanders (2002).
2. Middle of default range of estimates (500 to 1000 L/hour).
3. See Table 4.1.CT.
4. The 90th percentile for ages 16 - <21 from Table 16-28 in USEPA (2011).
5. Assumes bathroom dimensions of 7 feet by 10 feet by 8 feet, which approximates a bathroom containing a sink, toilet, and shower stall.
6. Chemical parameter values for constituents of potential concern obtained from the USEPA (2012) Regional Screening Levels (RSLs) tables. Chemical parameter values for radon obtained from McKone (1987).
7. Fraction volatilized (*f*) values were estimated using the reported *f* for radon (63%) during showers in Pritchard and Gesell (1981) as cited by Andelman (1990).

References:


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Jo, W.K., C.P. Weisel and P.J. Lioy. 1990. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal., vol 10, pp. 575-580.

Keating, G.A., McKone, T.E., and J.W. Gillett. 1997. Measured and estimated air concentrations of chloroform in showers: effects of water temperature and aerosols. Atmos. Environ, vol. 31, pp. 123-130.

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Moya, J., C. Howard-Reed, and R.L. Corsi. 1999. Volatilization of chemicals from tap water to indoor air from contaminated water used for showering. Environ. Sci. Technol., vol. 33, no. 14, pp. 2321-2327.

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Schaum, J., K. Hoang, R. Kinerson, J. Moya and R.G.M. Wang. 1994. Estimating dermal and inhalation exposure to volatile chemicals in domestic water. Water Contamination and Health. R.G.M. Wang, ed. Marcel Dekker, Inc., New York, pp.305-321.

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**Appendix B**
**Shower Model Calculations (Hypothetical Future Youth Resident)**
**Central Tendency Exposure**
**Ringwood Mines/Landfill Superfund Site**

| |
|---|
| Scenario Timeframe : Future |
| Medium : Groundwater |
| Exposure Medium : Groundwater |

| Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Model Equations |
|---|---|---|---|---|---|
| T | Temperature | 305 | K | Sanders 2002 (1) | |
| $F_w$ | Shower Water Flow Rate | 500 | L/hour | Schaum et al. 1994 (2) | Concentration in Air ($C_A$) = $((C_{amax}/2)\ t_1 + C_{amax}t_2)/(t_1+t_2)$ |
| $t_1$ | Time Spent Showering | 0.30 | hour | USEPA 2011 (3),(4) | $C_{amax} = C_W\ f\ F_W\ t_1 / V_a$ |
| $t_2$ | Time Spent in Bathroom after Showering | 0.12 | hour | USEPA 2011 (3),(4) | $f_i = f_j\ (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_j / (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_i$ |
| $V_a$ | Bathroom Air Volume | 16 | $m^3$ | Schaum et al. 1994 (5) | |
| R | Gas Constant | 8.21E-05 | atm-$m^3$/mol-K | Schaum et al. 1994 | |

| **CAS Number** | **Chemical of Potential Concern** | **Exposure Point Concentration in Groundwater $C_w$ (µg/L)** | **Henry's Law Constant (6) H (atm-$m^3$/mol)** | **Molecular Weight (6) MW (g/mol)** | **Diffusivity in Air (6) $D_a$ ($m^2$/sec)** | **Diffusivity in Water (6) $D_w$ ($m^2$/sec)** | **Mass-Transfer Coefficient K (cm/hr)** | **Fraction Volatilized (7) *f* (unitless)** | **Maximum Concentration in Air $C_{a,\ max}$ (µg/$m^3$)** | **Exposure Point Concentration in Air $C_a$ (µg/$m^3$)** |
|---|---|---|---|---|---|---|---|---|---|---|
| 10043-92-2 | Radon | NA | 9.21E-02 | 2.22E+02 | 2.00E-05 | 1.40E-09 | 2.00E+06 | 0.63 | NA | NA |
| 75-34-3 | 1,1-Dichloroethane | 8.3E-01 | 5.62E-03 | 9.90E+01 | 8.36E-06 | 1.06E-09 | 2.42E+06 | 0.52 | 4.06E+00 | 2.61E+00 |
| 71-43-2 | Benzene | 1.5E+00 | 5.55E-03 | 7.81E+01 | 8.95E-06 | 1.03E-09 | 2.46E+06 | 0.51 | 7.17E+00 | 4.61E+00 |
| 1634-04-4 | Methyl tert butyl ether | 1.3E+00 | 5.87E-04 | 8.82E+01 | 7.53E-06 | 8.59E-10 | 2.88E+06 | 0.44 | 5.38E+00 | 3.46E+00 |
| 91-20-3 | Naphthalene | 3.1E-01 | 4.40E-04 | 1.28E+02 | 6.05E-06 | 8.38E-10 | 2.98E+06 | 0.42 | 1.23E+00 | 7.93E-01 |
| 108-88-3 | Toluene | 5.7E+00 | 6.64E-03 | 9.21E+01 | 7.78E-06 | 9.20E-10 | 2.65E+06 | 0.47 | 2.55E+01 | 1.64E+01 |
| 79-01-6 | Trichloroethene | 2.6E-01 | 9.85E-03 | 1.31E+02 | 6.87E-06 | 1.02E-09 | 2.47E+06 | 0.51 | 1.25E+00 | 8.06E-01 |
| 1330-20-7 | Xylenes | 2.9E+00 | 5.18E-03 | 1.06E+02 | 8.47E-06 | 9.90E-10 | 2.53E+06 | 0.50 | 1.34E+01 | 8.64E+00 |

Notes:

1. Average of the temperatures (21-46 degrees Celsius) reported in shower model studies from the literature (Keating et al. 1997; Giardino and Andelman 1996; Jo et al. 1990; and Moya et al. 1999) as summarized by Sanders (2002).
2. Low end of default range of estimates (500 to 1000 L/hour).
3. See Table 4.1.CT.
4. The age-weighted mean for ages 7 - 16 from Table 16-28 in USEPA (2011).
5. Assumes bathroom dimensions of 7 feet by 10 feet by 8 feet, which approximates a bathroom containing a sink, toilet, and shower stall.
6. Chemical parameter values for constituents of potential concern obtained from the USEPA (2012) Regional Screening Levels (RSLs) tables. Chemical parameter values for radon obtained from McKone (1987).
7. Fraction volatilized (*f*) values were estimated using the reported *f* for radon (63%) during showers in Pritchard and Gesell (1981) as cited by Andelman (1990).

References:


Andelman, J.B. 1990. Total exposure to volatile organic compounds in potable water. Significance and Treatment of Volatile Organic Compounds in Water Supplies. N.M. Ram, R.F. Christman and K.P. Cantor, eds. Lewis Publishers, Chelsea, Michigan, pp. 485-504.

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Jo, W.K., C.P. Weisel and P.J. Lioy. 1990. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal., vol 10, pp. 575-580.

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**Appendix B**
**Shower Model Calculations (Hypothetical Future Youth Resident)**
**Reasonable Maximum Exposure**
**Ringwood Mines/Landfill Superfund Site**

| |
|---|
| Scenario Timeframe : Future |
| Medium : Groundwater |
| Exposure Medium : Groundwater |

| Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Model Equations |
|---|---|---|---|---|---|
| $T$ | Temperature | 305 | K | Sanders 2002 (1) | |
| $F_w$ | Shower Water Flow Rate | 750 | L/hour | Schaum et al. 1994 (2) | Concentration in Air ($C_A$) = $((C_{amax}/2)\ t_1 + C_{amax}t_2)/(t_1+t_2)$ |
| $t_1$ | Time Spent Showering | 0.52 | hour | USEPA 2011 (3),(4) | $C_{amax} = C_W\ f\ F_W\ t_1 / V_a$ |
| $t_2$ | Time Spent in Bathroom after Showering | 0.27 | hour | USEPA 2011 (3),(4) | $f_i = f_j\ (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_j / (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_i$ |
| $V_a$ | Bathroom Air Volume | 16 | $m^3$ | Schaum et al. 1994 (5) | |
| $R$ | Gas Constant | 8.21E-05 | atm-$m^3$/mol-K | Schaum et al. 1994 | |

| CAS Number | Chemical of Potential Concern | Exposure Point Concentration in Groundwater $C_w$ (µg/L) | Henry's Law Constant (6) H (atm-$m^3$/mol) | Molecular Weight (6) MW (g/mol) | Diffusivity in Air (6) $D_a$ ($m^2$/sec) | Diffusivity in Water (6) $D_w$ ($m^2$/sec) | Mass-Transfer Coefficient K (cm/hr) | Fraction Volatilized (7) $f$ (unitless) | Maximum Concentration in Air $C_{a,max}$ (µg/$m^3$) | Exposure Point Concentration in Air $C_a$ (µg/$m^3$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10043-92-2 | Radon | NA | 9.21E-02 | 2.22E+02 | 2.00E-05 | 1.40E-09 | 2.00E+06 | 0.63 | NA | NA |
| 75-34-3 | 1,1-Dichloroethane | 8.3E-01 | 5.62E-03 | 9.90E+01 | 8.36E-06 | 1.06E-09 | 2.42E+06 | 0.52 | 1.06E+01 | 7.08E+00 |
| 71-43-2 | Benzene | 1.5E+00 | 5.55E-03 | 7.81E+01 | 8.95E-06 | 1.03E-09 | 2.46E+06 | 0.51 | 1.86E+01 | 1.25E+01 |
| 1634-04-4 | Methyl tert butyl ether | 1.3E+00 | 5.87E-04 | 8.82E+01 | 7.53E-06 | 8.59E-10 | 2.88E+06 | 0.44 | 1.40E+01 | 9.39E+00 |
| 91-20-3 | Naphthalene | 3.1E-01 | 4.40E-04 | 1.28E+02 | 6.05E-06 | 8.38E-10 | 2.98E+06 | 0.42 | 3.21E+00 | 2.15E+00 |
| 108-88-3 | Toluene | 5.7E+00 | 6.64E-03 | 9.21E+01 | 7.78E-06 | 9.20E-10 | 2.65E+06 | 0.47 | 6.63E+01 | 4.45E+01 |
| 79-01-6 | Trichloroethene | 2.6E-01 | 9.85E-03 | 1.31E+02 | 6.87E-06 | 1.02E-09 | 2.47E+06 | 0.51 | 3.26E+00 | 2.19E+00 |
| 1330-20-7 | Xylenes | 2.9E+00 | 5.18E-03 | 1.06E+02 | 8.47E-06 | 9.90E-10 | 2.53E+06 | 0.50 | 3.49E+01 | 2.34E+01 |

Notes:

1. Average of the temperatures (21-46 degrees Celsius) reported in shower model studies from the literature (Keating et al. 1997; Giardino and Andelman 1996; Jo et al. 1990; and Moya et al. 1999) as summarized by Sanders (2002).
2. Middle of default range of estimates (500 to 1000 L/hour).
3. See Table 4.1.CT.
4. The age-weighted average of 90th percentile values for ages 7 - 16 from Table 16-28 in USEPA (2011).
5. Assumes bathroom dimensions of 7 feet by 10 feet by 8 feet, which approximates a bathroom containing a sink, toilet, and shower stall.
6. Chemical parameter values for constituents of potential concern obtained from the USEPA (2012) Regional Screening Levels (RSLs) tables. Chemical parameter values for radon obtained from McKone (1987).
7. Fraction volatilized ($f$) values were estimated using the reported $f$ for radon (63%) during showers in Pritchard and Gesell (1981) as cited by Andelman (1990).

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Giardino, N.J. and J.B. Andelman. 1996. Characterization of the emissions of trichloroethylene, chloroform, and 1,2-dibromo-3-chloropropane in a full-size experimental shower. J. Exposure Anal. Environ. Epidemiol., vol. 6, pp. 413-423.

Jo, W.K., C.P. Weisel and P.J. Lioy. 1990. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal., vol 10, pp. 575-580.

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**Appendix B**
**Shower Model Calculations (Hypothetical Future Child Resident)**
**Central Tendency Exposure**
**Ringwood Mines/Landfill Superfund Site**

| |
|---|
| Scenario Timeframe : Future |
| Medium : Groundwater |
| Exposure Medium : Groundwater |

| Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Model Equations |
|---|---|---|---|---|---|
| T | Temperature | 305 | K | Sanders 2002 (1) | |
| $F_w$ | Shower Water Flow Rate | 500 | L/hour | Schaum et al. 1994 (2) | Concentration in Air ($C_A$) = $((C_{amax}/2)\ t_1 + C_{amax}t_2)/(t_1+t_2)$ |
| $t_1$ | Time Spent Showering | 0.31 | hour | USEPA 2011 (3),(4) | $C_{amax} = C_W\ f\ F_W\ t_1 / V_a$ |
| $t_2$ | Time Spent in Bathroom after Showering | 0.12 | hour | USEPA 2011 (3),(4) | $f_i = f_j\ (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_j / (2.5/D_W^{0.67} + RT/D_a^{0.67}\ H)_i$ |
| $V_a$ | Bathroom Air Volume | 16 | $m^3$ | Schaum et al. 1994 (5) | |
| R | Gas Constant | 8.21E-05 | atm-$m^3$/mol-K | Schaum et al. 1994 | |

| CAS Number | Chemical of Potential Concern | Exposure Point Concentration in Groundwater $C_w$ (µg/L) | Henry's Law Constant (6) H (atm-$m^3$/mol) | Molecular Weight (6) MW (g/mol) | Diffusivity in Air (6) $D_a$ ($m^2$/sec) | Diffusivity in Water (6) $D_w$ ($m^2$/sec) | Mass-Transfer Coefficient K (cm/hr) | Fraction Volatilized (7) *f* (unitless) | Maximum Concentration in Air $C_{a,\ max}$ (µg/$m^3$) | Exposure Point Concentration in Air $C_a$ (µg/$m^3$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10043-92-2 | Radon | NA | 9.21E-02 | 2.22E+02 | 2.00E-05 | 1.40E-09 | 2.00E+06 | 0.63 | NA | NA |
| 75-34-3 | 1,1-Dichloroethane | 8.3E-01 | 5.62E-03 | 9.90E+01 | 8.36E-06 | 1.06E-09 | 2.42E+06 | 0.52 | 4.20E+00 | 2.68E+00 |
| 71-43-2 | Benzene | 1.5E+00 | 5.55E-03 | 7.81E+01 | 8.95E-06 | 1.03E-09 | 2.46E+06 | 0.51 | 7.41E+00 | 4.74E+00 |
| 1634-04-4 | Methyl tert butyl ether | 1.3E+00 | 5.87E-04 | 8.82E+01 | 7.53E-06 | 8.59E-10 | 2.88E+06 | 0.44 | 5.56E+00 | 3.56E+00 |
| 91-20-3 | Naphthalene | 3.1E-01 | 4.40E-04 | 1.28E+02 | 6.05E-06 | 8.38E-10 | 2.98E+06 | 0.42 | 1.27E+00 | 8.15E-01 |
| 108-88-3 | Toluene | 5.7E+00 | 6.64E-03 | 9.21E+01 | 7.78E-06 | 9.20E-10 | 2.65E+06 | 0.47 | 2.64E+01 | 1.69E+01 |
| 79-01-6 | Trichloroethene | 2.6E-01 | 9.85E-03 | 1.31E+02 | 6.87E-06 | 1.02E-09 | 2.47E+06 | 0.51 | 1.30E+00 | 8.29E-01 |
| 1330-20-7 | Xylenes | 2.9E+00 | 5.18E-03 | 1.06E+02 | 8.47E-06 | 9.90E-10 | 2.53E+06 | 0.50 | 1.39E+01 | 8.88E+00 |

Notes:

1. Average of the temperatures (21-46 degrees Celsius) reported in shower model studies from the literature (Keating et al. 1997; Giardino and Andelman 1996; Jo et al. 1990; and Moya et al. 1999) as summarized by Sanders (2002).
2. Low end of default range of estimates (500 to 1000 L/hour).
3. See Table 4.1.CT.
4. The age-weighted mean for ages 1 - 6 from Table 16-28 in USEPA (2011).
5. Assumes bathroom dimensions of 7 feet by 10 feet by 8 feet, which approximates a bathroom containing a sink, toilet, and shower stall.
6. Chemical parameter values for constituents of potential concern obtained from the USEPA (2012) Regional Screening Levels (RSLs) tables. Chemical parameter values for radon obtained from McKone (1987).
7. Fraction volatilized (*f*) values were estimated using the reported *f* for radon (63%) during showers in Pritchard and Gesell (1981) as cited by Andelman (1990).

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Jo, W.K., C.P. Weisel and P.J. Lioy. 1990. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal., vol 10, pp. 575-580.

Keating, G.A., McKone, T.E., and J.W. Gillett. 1997. Measured and estimated air concentrations of chloroform in showers: effects of water temperature and aerosols. Atmos. Environ, vol. 31, pp. 123-130.

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Moya, J., C. Howard-Reed, and R.L. Corsi. 1999. Volatilization of chemicals from tap water to indoor air from contaminated water used for showering. Environ. Sci. Technol., vol. 33, no. 14, pp. 2321-2327.

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**Appendix B**
**Shower Model Calculations (Hypothetical Future Child Resident)**
**Reasonable Maximum Exposure**
**Ringwood Mines/Landfill Superfund Site**

| |
|---|
| Scenario Timeframe : Future |
| Medium : Groundwater |
| Exposure Medium : Groundwater |

| Parameter Code | Parameter Definition | Value | Units | Rationale/ Reference | Model Equations |
|---|---|---|---|---|---|
| T | Temperature | 305 | K | Sanders 2002 (1) | |
| $F_w$ | Shower Water Flow Rate | 750 | L/hour | Schaum et al. 1994 (2) | Concentration in Air ($C_A$) = (($C_{amax}$/2) $t_1$ + $C_{amax}t_2$)/($t_1$+$t_2$) |
| $t_1$ | Time Spent Showering | 0.50 | hour | USEPA 2011 (3),(4) | $C_{amax} = C_W f\ F_W t_1 / V_a$ |
| $t_2$ | Time Spent in Bathroom after Showering | 0.22 | hour | USEPA 2011 (3),(4) | $f_i = f_j\ (2.5/D_W^{0.67} + RT/D_a^{0.67} H)_j / (2.5/D_W^{0.67} + RT/D_a^{0.67} H)_i$ |
| $V_a$ | Bathroom Air Volume | 16 | $m^3$ | Schaum et al. 1994 (5) | |
| R | Gas Constant | 8.21E-05 | atm-$m^3$/mol-K | Schaum et al. 1994 | |

| **CAS Number** | **Chemical of Potential Concern** | **Exposure Point Concentration in Groundwater $C_w$ (µg/L)** | **Henry's Law Constant (6) H (atm-$m^3$/mol)** | **Molecular Weight (6) MW (g/mol)** | **Diffusivity in Air (6) $D_a$ ($m^2$/sec)** | **Diffusivity in Water (6) $D_w$ ($m^2$/sec)** | **Mass-Transfer Coefficient K (cm/hr)** | **Fraction Volatilized (7) *f* (unitless)** | **Maximum Concentration in Air $C_{a, max}$ (µg/$m^3$)** | **Exposure Point Concentration in Air $C_a$ (µg/$m^3$)** |
|---|---|---|---|---|---|---|---|---|---|---|
| 10043-92-2 | Radon | NA | 9.21E-02 | 2.22E+02 | 2.00E-05 | 1.40E-09 | 2.00E+06 | 0.63 | NA | NA |
| 75-34-3 | 1,1-Dichloroethane | 8.3E-01 | 5.62E-03 | 9.90E+01 | 8.36E-06 | 1.06E-09 | 2.42E+06 | 0.52 | 1.01E+01 | 6.63E+00 |
| 71-43-2 | Benzene | 1.5E+00 | 5.55E-03 | 7.81E+01 | 8.95E-06 | 1.03E-09 | 2.46E+06 | 0.51 | 1.79E+01 | 1.17E+01 |
| 1634-04-4 | Methyl tert butyl ether | 1.3E+00 | 5.87E-04 | 8.82E+01 | 7.53E-06 | 8.59E-10 | 2.88E+06 | 0.44 | 1.35E+01 | 8.79E+00 |
| 91-20-3 | Naphthalene | 3.1E-01 | 4.40E-04 | 1.28E+02 | 6.05E-06 | 8.38E-10 | 2.98E+06 | 0.42 | 3.08E+00 | 2.01E+00 |
| 108-88-3 | Toluene | 5.7E+00 | 6.64E-03 | 9.21E+01 | 7.78E-06 | 9.20E-10 | 2.65E+06 | 0.47 | 6.38E+01 | 4.16E+01 |
| 79-01-6 | Trichloroethene | 2.6E-01 | 9.85E-03 | 1.31E+02 | 6.87E-06 | 1.02E-09 | 2.47E+06 | 0.51 | 3.14E+00 | 2.05E+00 |
| 1330-20-7 | Xylenes | 2.9E+00 | 5.18E-03 | 1.06E+02 | 8.47E-06 | 9.90E-10 | 2.53E+06 | 0.50 | 3.36E+01 | 2.19E+01 |

Notes:

1. Average of the temperatures (21-46 degrees Celsius) reported in shower model studies from the literature (Keating et al. 1997; Giardino and Andelman 1996; Jo et al. 1990; and Moya et al. 1999) as summarized by Sanders (2002).
2. Middle of default range of estimates (500 to 1000 L/hour).
3. See Table 4.1.CT.
4. The age-weighted average of 90th percentile values for ages 1 - 6 from Table 16-28 in USEPA (2011).
5. Assumes bathroom dimensions of 7 feet by 10 feet by 8 feet, which approximates a bathroom containing a sink, toilet, and shower stall.
6. Chemical parameter values for constituents of potential concern obtained from the USEPA (2012) Regional Screening Levels (RSLs) tables. Chemical parameter values for radon obtained from McKone (1987).
7. Fraction volatilized (*f*) values were estimated using the reported *f* for radon (63%) during showers in Pritchard and Gesell (1981) as cited by Andelman (1990).

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**Appendix C**

Mutagenic Exposure Calculations

**Appendix C**
**Intakes for Cancer Risk Calculations for COPCs Considered Mutagenic**
**Central Tendency Exposure**
**Ringwood Mines/Landfill Superfund Site**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth [1]

| Constituent | EPC (ug/L) | EPC ($ug/m^3$) | ADAF 7 - <16 yrs | INTAKE (MG/KG-DAY) OR ($UG/M^3$) 7 - <16 years Ingestion | Dermal | Inhalation |
|---|---|---|---|---|---|---|
| Trichloroethene | 2.6E-01 | 8.1E-01 | 3 | 3.5E-07 | 1.3E-07 | 1.7E-03 |
| Chromium | 4.3E+00 | NA | 3 | 5.7E-06 | 1.0E-07 | NA |

Notes:
Intake for cancer risk calculations was calculated using the following equation for ingestion for each portion of life:
EPC * CF * IRW * EF * EDx-y * ADAFx-y * 1/BW * 1/ATc
Intake for cancer risk calculations was calculated using the following equation for dermal contact for each portion of life:
EPC * CF1 * CF2 * DAevent * EvF * EF * EDx-y *ADAFx-y * SA * 1/BW * 1/ATc
Intake for cancer risk calculations was calculated using the following equation for inhalation for each portion of life:
EPC * ET * EvF * EF * EDx-y *ADAFx-y * 1/ATc
[1] Youth is assumed to be 7 to 16 years of age, but only the first 3 years are evaluated under the CT scenario.
ADAF = Age-dependent adjustment factor
EPC = Exposure point concentration
mg/kg-day = Milligrams per kilogram per day
ug/L = Micrograms per liter
$ug/m^3$ = Micrograms per cubic meter

**Appendix C**

**Intakes for Cancer Risk Calculations for COPCs Considered Mutagenic**

**Reasonable Maximum Exposure**

**Ringwood Mines/Landfill Superfund Site**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Youth [1]

| Constituent | EPC (ug/L) | EPC (ug/m$^3$) | ADAF 7 - <16 yrs | ADAF 16 - <17 yrs | INTAKE (MG/KG-DAY) OR (UG/M$^3$) 7 - <16 years Ingestion | 7 - <16 years Dermal | 7 - <16 years Inhalation | 16 - <17 years Ingestion | 16 - <17 years Dermal | 16 - <17 years Inhalation | TOTAL INTAKE (MG/KG-DAY) OR (UG/M$^3$) Ingestion | Dermal | Inhalation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trichloroethene | 2.6E-01 | 2.2E+00 | 3 | 1 | 4.3E-06 | 5.3E-07 | 2.7E-02 | 1.6E-07 | 2.0E-08 | 9.9E-04 | 4.5E-06 | 5.5E-07 | 2.8E-02 |
| Chromium | 4.3E+00 | NA | 3 | 1 | 7.1E-05 | 5.2E-07 | NA | 2.6E-06 | 1.9E-08 | NA | 7.4E-05 | 5.4E-07 | NA |

Notes:

Intake for cancer risk calculations was calculated using the following equation for ingestion for each portion of life:

EPC * CF * IRW * EF * EDx-y * ADAFx-y * 1/BW * 1/ATc

Intake for cancer risk calculations was calculated using the following equation for dermal contact for each portion of life:

EPC * CF1 * CF2 * DAevent * EvF * EF * EDx-y *ADAFx-y * SA * 1/BW * 1/ATc

Intake for cancer risk calculations was calculated using the following equation for inhalation for each portion of life:

EPC * ET * EvF * EF * EDx-y *ADAFx-y * 1/ATc

[1] Youth is assumed to be 7 to 16 years of age.

ADAF = Age-dependent adjustment factor
EPC = Exposure point concentration
mg/kg-day = Milligrams per kilogram per day
ug/L = Micrograms per liter
ug/m$^3$ = Micrograms per cubic meter

**Appendix C**

**Intakes for Cancer Risk Calculations for COPCs Considered Mutagenic**

**Central Tendency Exposure**

**Ringwood Mines/Landfill Superfund Site**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child [1]

| Constituent | EPC (ug/L) | EPC ($ug/m^3$) | ADAF 1 - <2 yrs | ADAF 2 - <7 yrs | INTAKE (MG/KG-DAY) OR ($UG/M^3$) 1 - <2 years Ingestion | Dermal | Inhalation | 2 - <7 years Ingestion | Dermal | Inhalation | TOTAL INTAKE (MG/KG-DAY) OR ($UG/M^3$) Ingestion | Dermal | Inhalation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trichloroethene | 2.6E-01 | 8.3E-01 | 10 | 3 | 7.9E-07 | 2.4E-07 | 2.0E-03 | 1.2E-06 | 3.6E-07 | 3.1E-03 | 2.0E-06 | 6.1E-07 | 5.1E-03 |
| Chromium | 4.3E+00 | NA | 10 | 3 | 1.3E-05 | 1.8E-07 | NA | 2.0E-05 | 2.8E-07 | NA | 3.3E-05 | 4.6E-07 | NA |

Notes:

Intake for cancer risk calculations was calculated using the following equation for ingestion for each portion of life:

EPC * CF * IRW * EF * EDx-y * ADAFx-y * 1/BW * 1/ATc

Intake for cancer risk calculations was calculated using the following equation for dermal contact for each portion of life:

EPC * CF1 * CF2 * DAevent * EvF * EF * EDx-y *ADAFx-y * SA * 1/BW * 1/ATc

Intake for cancer risk calculations was calculated using the following equation for inhalation for each portion of life:

EPC * ET * EvF * EF * EDx-y *ADAFx-y * 1/ATc

[1] Young child is assumed to be 1 to 6 years of age.

ADAF = Age-dependent adjustment factor
EPC = Exposure point concentration
mg/kg-day = Milligrams per kilogram per day
ug/L = Micrograms per liter
$ug/m^3$ = Micrograms per cubic meter

**Appendix C**

**Intakes for Cancer Risk Calculations for COPCs Considered Mutagenic**

**Reasonable Maximum Exposure**

**Ringwood Mines/Landfill Superfund Site**

Scenario Timeframe: Future
Receptor Population: Hypothetical Future Resident
Receptor Age: Young Child [1]

| Constituent | EPC (ug/L) | EPC (ug/m$^3$) | ADAF 1 - <2 yrs | ADAF 2 - <7 yrs | INTAKE (MG/KG-DAY) OR (UG/M$^3$) 1 - <2 years Ingestion | Dermal | Inhalation | 2 - <7 years Ingestion | Dermal | Inhalation | TOTAL INTAKE (MG/KG-DAY) OR (UG/M$^3$) Ingestion | Dermal | Inhalation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trichloroethene | 2.6E-01 | 2.0E+00 | 10 | 3 | 2.4E-06 | 3.1E-07 | 8.4E-03 | 3.6E-06 | 4.6E-07 | 1.3E-02 | 6.0E-06 | 7.7E-07 | 2.1E-02 |
| Chromium | 4.3E+00 | NA | 10 | 3 | 4.0E-05 | 3.0E-07 | NA | 5.9E-05 | 4.5E-07 | NA | 9.9E-05 | 7.4E-07 | NA |

Notes:

Intake for cancer risk calculations was calculated using the following equation for ingestion for each portion of life:

EPC * CF * IRW * EF * EDx-y * ADAFx-y * 1/BW * 1/ATc

Intake for cancer risk calculations was calculated using the following equation for dermal contact for each portion of life:

EPC * CF1 * CF2 * DAevent * EvF * EF * EDx-y *ADAFx-y * SA * 1/BW * 1/ATc

Intake for cancer risk calculations was calculated using the following equation for inhalation for each portion of life:

EPC * ET * EvF * EF * EDx-y *ADAFx-y * 1/ATc

[1] Young child is assumed to be 1 to 6 years of age.

ADAF = Age-dependent adjustment factor
EPC = Exposure point concentration
mg/kg-day = Milligrams per kilogram per day
ug/L = Micrograms per liter
ug/m$^3$ = Micrograms per cubic meter